

# Module Handbook Master Program in Mechanical Engineering (M.Sc.)

Valid from Winter Term 2014/2015

Long version

Date: 10/01/2014

Faculty of Mechanical Engineering



Publisher:

Faculty of Mechanical Engineering  
Karlsruhe Institute of Technology (KIT)  
76128 Karlsruhe  
[www.mach.kit.edu](http://www.mach.kit.edu)

Frontpage Image: Rolls-Royce plc

Contact: [rainer.schwarz@kit.edu](mailto:rainer.schwarz@kit.edu)

For informational use only. For legally binding information please refer to the german version of the handbook.

## Table of Contents

|  |           |
|--|-----------|
| <b>1 Studienplan</b>   | <b>17</b> |
| <b>2 Learning Outcomes</b>   | <b>35</b> |
| <b>3 Module</b>  | <b>36</b> |
| 3.1 Wahlpflichtfach  | 36        |
| Compulsory Elective Subject General Mechanical Engineering- MSc-Modul AM, WPF AM               | 36        |
| Compulsory Elective Subject E+U- MSc-Modul E+U, WPF E+U  | 38        |
| Compulsory Elective Subject FzgT- MSc-Modul FzgT, WPF FzgT                                     | 39        |
| Compulsory Elective Subject M+M- MSc-Modul M+M, WPF M+M  | 41        |
| Compulsory Elective Subject PEK- MSc-Modul PEK, WPF PEK  | 43        |
| Compulsory Elective Subject PT- MSc-Modul PT, WPF PT   | 44        |
| Compulsory Elective Subject ThM- MSc-Modul ThM, WPF ThM  | 45        |
| Compulsory Elective Subject W+S- MSc-Modul W+S, WPF W+S  | 46        |
| 3.2 Wahlfach   | 47        |
| Elective Subject- MSc-Modul 04, WF   | 47        |
| 3.3 Modellbildung und Simulation   | 54        |
| Modeling and Simulation- MSc-Modul 05, MS  | 54        |
| 3.4 Produktentstehung  | 55        |
| Product Development- MSc-Modul 06, PE  | 55        |
| 3.5 Fachpraktikum  | 56        |
| Specialized Practical Training- MSc-Modul 07, FP   | 56        |
| 3.6 Mathematische Methoden im Masterstudiengang  | 57        |
| Mathematic Methods- MSc-Modul 08, MM   | 57        |
| 3.7 Schwerpunkt  | 58        |
| Major Field 1- MSc-Modul 09, SP 1  | 58        |
| Major Field 2- MSc-Modul 10, SP 2  | 59        |
| 3.8 Wahlfach Nat/inf/etit  | 60        |
| Elective Subject Natural Science/Computer Science/Electrical Engineering- MSc-Modul 11, WF NIE | 60        |
| 3.9 Wahlfach Wirtschaft/Recht  | 61        |
| Elective Subject Economics/Law- MSc-Modul 12, WF WR  | 61        |
| 3.10 Veranstaltungen in englischer Sprache   | 62        |
| Lectures in English (M.Sc.)- Englischsprachige Veranstaltungen (M.Sc.)                         | 62        |
| <b>4 Courses</b>   | <b>64</b> |
| 4.1 All Courses  | 64        |
| Analysis of Exhaust Gas und Lubricating Oil in Combustion Engines- 2134150                     | 64        |
| Adaptive Control Systems- 2105012  | 65        |
| Aerodynamics- 2154420  | 66        |
| Aerothermodynamics- 2154436  | 67        |
| Applied Tribology in Industrial Product Development- 2145181                                   | 68        |
| Applied Materials Modelling- 2181614   | 69        |
| Drive Train of Mobile Machines- 2113077  | 70        |
| Application of technical logistics in modern crane systems- 2117064                            | 71        |
| Application of technical logistics in sorting- and distribution technology- 2118089            | 72        |
| Application of advanced programming languages in mechanical engineering- 2182735               | 73        |
| Applied Combustion Technology- 22528   | 74        |
| Human Factors Engineering I- 2109035   | 75        |
| Human Factors Engineering II- 2109036  | 77        |
| Atomistic simulations and molecular dynamics- 2181740  | 78        |
| Constitution and Properties of Wear resistant materials- 2194643                               | 79        |
| Constitution and Properties of Protective Coatings- 2177601                                    | 80        |
| Selected Applications of Technical Logistics- 2118087  | 81        |
| Selected Topics in Aeronautics and Astronautics I- 2170454                                     | 82        |

|   |     |
|---|-----|
| Selected Topics in Aeronautics and Astronautics II- 2169486                                       | 83  |
| Selected Topics on Optics and Microoptics for Mechanical Engineers- 2143892                       | 84  |
| Selected chapters of the combustion fundamentals- 2167541   | 85  |
| Selected Problems of Applied Reactor Physics and Exercises- 2190411                               | 86  |
| Design of highly stresses components- 2181745   | 87  |
| Design and Development of Mobile Machines- 2113079  | 88  |
| Dimensioning and Optimization of Power Train System- 2146208                                      | 89  |
| Automation Systems- 2106005   | 90  |
| Automotive Engineering I- 2113809   | 91  |
| Rail System Technology- 2115919   | 92  |
| Basics of Liberalised Energy Markets- 2581998   | 93  |
| Fuels and Lubricants for Combustion Engines- 2133108  | 94  |
| BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I- 2141864                     | 95  |
| BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II- 2142883                    | 96  |
| BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III- 2142879                   | 97  |
| BUS-Controls- 2114092   | 98  |
| CAE-Workshop- 2147175   | 99  |
| CFD for Power Engineering- 2130910  | 100 |
| Chemical Fuels- 2199115   | 101 |
| Computational Intelligence I- 2106004   | 102 |
| Computational Intelligence II- 2105015  | 103 |
| Computational Intelligence III- 2106020   | 104 |
| Decentrally controlled intralogistic systems- 2117084   | 105 |
| Railways in the Transportation Market- 2114914  | 106 |
| Finite Difference Methods for numerical solution of thermal and fluid dynamical problems- 2153405 | 107 |
| Digital Control- 2137309  | 108 |
| Designing with numerical methods in product development- 2161229                                  | 109 |
| Designing with composites- 2162255  | 110 |
| Dynamics of the Automotive Drive Train- 2163111   | 111 |
| Introduction in Human Factors Engineering- 3110041  | 112 |
| Introduction to the Finite Element Method- 2162282  | 113 |
| Introduction to Nuclear Energy- 2189903   | 114 |
| Introduction to Nuclear Engineering- 2130974  | 115 |
| Introduction to Theory of Materials- 2182732  | 116 |
| Introduction to the Mechanics of Composite Materials- 2178734                                     | 117 |
| Introduction into Mechatronics- 2105011   | 118 |
| Introduction into the multi-body dynamics- 2162235  | 119 |
| Introduction to modeling of aerospace systems- 2154430  | 120 |
| Introduction to numerical mechanics- 2161226  | 121 |
| Introduction to Nonlinear Vibrations- 2162247   | 122 |
| Electric Power Generation and Power Grid- 2300002   | 124 |
| Electrical Machines- 23315  | 125 |
| Electrical Power Transmission and Grid Control- 2199120   | 127 |
| Electric Rail Vehicles- 2114346   | 128 |
| Electrical Engineering II- 23224  | 129 |
| Elements of Technical Logistics- 2117096  | 130 |
| Elements of Technical Logistics and Project- 2117097  | 131 |
| Energy and Process Technology I- 2157961  | 132 |
| Energy and Process Technology II- 2170832   | 133 |
| Energy efficient intralogistic systems- 2117500   | 134 |
| Energy Systems I: Renewable Energy- 2129901   | 135 |
| Energy Systems II: Nuclear Energy and Reactor Technology- 2130921                                 | 136 |
| Organ support systems- 2106008  | 137 |
| Experimental Fluid Mechanics- 2154446   | 138 |
| Metallographic Lab Class- 2175590   | 139 |
| The Management of R&D Projects with Case Studies- 2581963   | 140 |
| Handling Characteristics of Motor Vehicles I- 2113807   | 141 |
| Handling Characteristics of Motor Vehicles II- 2114838  | 142 |

|   |     |
|---|-----|
| Vehicle Comfort and Acoustics I- 2113806 . . . . .  | 143 |
| Vehicle Comfort and Acoustics II- 2114825 . . . . .   | 144 |
| Introduction to Automotive Lightweight Technology- 2113102 . . . . .  | 145 |
| Vehicle Mechatronics I- 2113816 . . . . .   | 146 |
| Basics and Methods for Integration of Tires and Vehicles- 2114845 . . . . .                                 | 147 |
| Automotive Vision- 2138340 . . . . .  | 148 |
| Composites for Lightweight Design- 2114053 . . . . .  | 149 |
| FEM Workshop – constitutive laws- 2183716 . . . . .   | 150 |
| Fabrication Processes in Microsystem Technology- 2143882 . . . . .  | 151 |
| Solid State Reactions and Kinetics of Phase Transformations (with exercises)- 2193003 . . . . .             | 152 |
| Finite Volume Methods for Fluid Flow- 2154431 . . . . .   | 153 |
| Fluid-Structure-Interaction- 2154401 . . . . .  | 154 |
| Fluid Technology- 2114093 . . . . .   | 155 |
| Fundamentals of Combustion I- 3165016 . . . . .   | 156 |
| Functional Ceramics- 2126784 . . . . .  | 157 |
| Fusion Technology A- 2169483 . . . . .  | 158 |
| Fusion Technology B- 2190492 . . . . .  | 159 |
| Combined Cycle Power Plants- 2170490 . . . . .  | 160 |
| - 2154200 . . . . .   | 161 |
| Gas Engines- 2134141 . . . . .  | 162 |
| Global vehicle evaluation within virtual road test- 2114850 . . . . .                                       | 163 |
| Foundry Technology- 2174575 . . . . .   | 164 |
| Global Production and Logistics - Part 1: Global Production- 2149610 . . . . .                              | 165 |
| Global Production and Logistics - Part 2: Global Logistics- 2149600 . . . . .                               | 167 |
| Size effects in micro and nanostructures materials- 2181744 . . . . .                                       | 169 |
| Fundamentals of Energy Technology- 2130927 . . . . .  | 170 |
| Automotive Engineering I- 2113805 . . . . .   | 171 |
| Automotive Engineering II- 2114835 . . . . .  | 172 |
| Grundlagen der Herstellungsverfahren der Keramik und Pulvermetallurgie- 2193010 . . . . .                   | 173 |
| Fundamentals of catalytic exhaust gas aftertreatment- 2134138 . . . . .                                     | 174 |
| Principles of Medicine for Engineers- 2105992 . . . . .   | 175 |
| Introduction to Microsystem Technology I- 2141861 . . . . .   | 176 |
| Introduction to Microsystem Technology II- 2142874 . . . . .  | 177 |
| Foundations of nonlinear continuum mechanics- 2181720 . . . . .   | 178 |
| Fundamentals of reactor safety for the operation and dismantling of nuclear power plants- 2190465 . . . . . | 179 |
| Fundamentals of X-ray Optics I- 2141007 . . . . .   | 180 |
| Basics of Technical Logistics- 2117095 . . . . .  | 181 |
| Fundamentals of Combustion I- 2165515 . . . . .   | 182 |
| Fundamentals of combustion II- 2166538 . . . . .  | 183 |
| Fundamentals of Combustion Engines I- 2133103 . . . . .   | 184 |
| Fundamentals of Combustion Engines II- 2134131 . . . . .  | 185 |
| Optical Flow Measurement: Fundamentals and Applications- 2153410 . . . . .                                  | 186 |
| Hardware/Software Codesign- 23620 . . . . .   | 187 |
| High Temperature Structural Materials- 2174600 . . . . .  | 188 |
| Human Biology- 2106040 . . . . .  | 189 |
| Hydraulic Fluid Machinery I (Basics)- 2157432 . . . . .   | 190 |
| Hydraulic Fluid Machinery II- 2158105 . . . . .   | 191 |
| Hydrodynamic Stability: From Order to Chaos- 2154437 . . . . .  | 192 |
| Industrial aerodynamics- 2153425 . . . . .  | 193 |
| Introduction to Industrial Production Economics- 2109042 . . . . .  | 194 |
| Occupational Safety and Environmental Protection (in German)- 2110037 . . . . .                             | 195 |
| Information Systems in Logistics and Supply Chain Management- 2118094 . . . . .                             | 197 |
| Innovation Workshop: Mobility concepts for the year 2050- 2115916 . . . . .                                 | 198 |
| Innovative Nuclear Systems- 2130973 . . . . .   | 199 |
| Introduction to Neutron Cross Section Theory and Nuclear Data Generation- 2190490 . . . . .                 | 200 |
| IT-Fundamentals of Logistics- 2118183 . . . . .   | 201 |
| Introduction to Ceramics- 2125757 . . . . .   | 203 |
| Ceramics Processing- 2126730 . . . . .  | 204 |

|   |     |
|---|-----|
| Nuclear Power Plant Technology- 2170460   | 205 |
| Coal fired power plants- 2169461  | 207 |
| Design with Plastics- 2174571   | 208 |
| Structural Materials- 2174580   | 209 |
| Lightweight Engineering Design - 2146190  | 210 |
| Vibration of continuous systems- 2161214  | 211 |
| Motor Vehicle Laboratory- 2115808   | 212 |
| Cooling of thermally high loaded gas turbine components- 2170463                              | 213 |
| Laboratory Work in Combustion Technology- 22531   | 214 |
| Warehousing and distribution systems- 2118097   | 215 |
| Laser in automotive engineering- 2182642  | 217 |
| Leadership and Product Development- 2145184   | 218 |
| Laboratory Exercise in Energy Technology- 2171487   | 219 |
| Logistics - organisation, design and control of logistic systems- 2118078                     | 220 |
| Automotive Logistics- 2118085   | 221 |
| Airport logistics- 2117056  | 222 |
| Machine Vision- 2137308   | 223 |
| Magnet Technology of Fusion Reactors- 2190496   | 224 |
| Magnetohydrodynamics- 2153429   | 225 |
| Leadership and Conflict Management (in German)- 2110017                                       | 226 |
| Machine Dynamics- 2161224   | 228 |
| Machine Dynamics II- 2162220  | 229 |
| Material flow in logistic systems- 2117051  | 230 |
| Materialien für elektrochemische Speicher und Wandler- 2174601                                | 231 |
| Materials and Processes for Body Lightweight Construction in the Automotive Industry- 2149669 | 232 |
| Mathematical Modelling and Simulation- 0109400  | 233 |
| Mathematical Foundation for Computational Mechanics- 2162240                                  | 234 |
| Mathematical Methods in Dynamics- 2161206   | 235 |
| Mathematical Methods in Strength of Materials- 2161254  | 236 |
| Mathematical methods of vibration theory- 2162241   | 238 |
| Mathematical Methods in Fluid Mechanics- 2154432  | 239 |
| Mathematical Methods in Structural Mechanics- 2162280   | 240 |
| Mathematical models and methods in combustion theory- 2165525                                 | 242 |
| Mathematical models and methods for Production Systems- 2117059                               | 243 |
| Mechanical Design I - 2145186   | 245 |
| Mechanics of laminated composites- 2161983  | 247 |
| Mechanics and Strengths of Polymers- 2173580  | 248 |
| Mechanics in Microtechnology- 2181710   | 249 |
| Mechanical Characteristics and Microstructure Characteristics Relationships- 2178120          | 250 |
| Laboratory mechatronics- 2105014  | 251 |
| Measurement II- 2138326   | 252 |
| Measurement Instrumentation Lab- 2138328  | 253 |
| Metals- 2174598   | 254 |
| Methods of Signal Processing- 23113   | 255 |
| Analysis tools for combustion diagnostics- 2134134  | 256 |
| Methodical Design of Composite Structures- 2114101  | 257 |
| Microoptics and Lithography- 2142884  | 258 |
| Microactuators- 2142881   | 259 |
| Microstructure characterization and modelling- 2161251  | 260 |
| Modelling of Microstructures- 2183702   | 261 |
| Mobile Machines- 2114073  | 263 |
| Model based Application Methods- 2134139  | 264 |
| Modelling and Simulation- 2185227   | 265 |
| Modeling of Thermodynamical Processes- 2167523  | 266 |
| Modelling and Simulation- 2183703   | 267 |
| - 2158206   | 268 |
| Modern Software Tools in Power Engineering- 2199119   | 269 |
| Modern Physics for Engineers- 4040311   | 270 |

|  |     |
|--|-----|
| Engine Laboratory- 2134001   | 271 |
| Engine measurement techniques- 2134137   | 272 |
| Nanotechnology for Engineers and Natural Scientists- 2142861                           | 273 |
| Nanotechnology with Clusterbeams- 2143876  | 274 |
| Nanotribology and -Mechanics- 2181712  | 275 |
| Novel actuators and sensors- 2141865   | 276 |
| Neutron physics of fusion reactors- 2189473  | 277 |
| Nonlinear Continuum Mechanics- 2162344   | 278 |
| Nuclear Fusion Technology- 2189920   | 279 |
| Nuclear Power and Reactor Technology- 2189921  | 280 |
| Numerical Mathematics- 01874   | 281 |
| Numerical mechanics for industrial applications- 2162298                               | 282 |
| Computational Methods in Fluid Mechanics- 2157441                                      | 283 |
| Numerical Modeling of Multiphase Flows- 2130934  | 284 |
| Numerical simulation of reacting two phase flows- 2169458                              | 285 |
| Numerical Simulation of Turbulent Flows- 2154449                                       | 286 |
| Public Law I - Basic Principles- 24016   | 287 |
| Optoelectronic Components- 23486 / 23487   | 288 |
| Intellectual Property Rights and Strategies in Industrial Companies- 2147161           | 289 |
| Patent Law- 24656  | 290 |
| Photovoltaics- 23737   | 291 |
| Physics for Engineers- 2142890   | 292 |
| Physical basics of laser technology- 2181612   | 293 |
| Planning of Assembly Systems (in German)- 2109034                                      | 295 |
| PLM for Product Development in Mechatronics- 2122376                                   | 296 |
| PLM in the Manufacturing Industry- 2121366   | 297 |
| Polymer Engineering I- 2173590   | 298 |
| Polymer Engineering II- 2174596  | 299 |
| Polymers in MEMS A: Chemistry, Synthesis and Applications- 2141853                     | 300 |
| Polymers in MEMS B: Physics, Microstructuring and Applications- 2141854                | 302 |
| Power Electronics- 2199102   | 304 |
| Laboratory "Laser Materials Processing"- 2183640                                       | 305 |
| Introduction to Microsystem Technology - Practical Course- 2143875                     | 306 |
| Product Lifecycle Management- 2121350  | 307 |
| Product, Process and Resource Integration in the Automotive Industry- 2123364          | 309 |
| Product Development - Methods of Product Development- 2146176                          | 310 |
| Product Development - Manufacturing and Material Technology- 2150510                   | 311 |
| Production Management I- 2109028   | 313 |
| Production Management II- 2110028  | 314 |
| Production Planning and Control- 2110032   | 315 |
| Production Techniques Laboratory- 2110678  | 317 |
| Productivity Management in Production Systems- 2110046                                 | 319 |
| Project Workshop: Automotive Engineering- 2115817                                      | 321 |
| Project Mikro Manufacturing: Design and Manufacturing of Micro Systems- 2149680        | 322 |
| Development of Oil-Hydraulic Powertrain Systems- 2113072                               | 323 |
| Project Management in Rail Industry- 2115995   | 324 |
| Project management in Global Product Engineering Structures- 2145182                   | 325 |
| Process Simulation in Forming Operations- 2161501                                      | 326 |
| Advanced powder metals- 2126749  | 327 |
| Quality Management- 2149667  | 328 |
| Range Extender- 2146440  | 330 |
| Reactor Safety I: Fundamentals- 2189465  | 331 |
| Computational Vehicle Dynamics- 2162256  | 332 |
| Computerized Multibody Dynamics- 2162216   | 333 |
| Computer Integrated Planning of New Products- 2122387                                  | 334 |
| Computational Mechanics I- 2161250   | 335 |
| Computational Mechanics II- 2162296  | 336 |
| Reduction methods for the modeling and the simulation of combustion processes- 2166543 | 337 |

|   |     |
|---|-----|
| Renewable Energy – Resources, Technology and Economics- 2581012 . . . . .                       | 338 |
| Rheometry and Rheology- 22949 . . . . .   | 339 |
| Rail Vehicle Technology- 2115996 . . . . .  | 340 |
| Fatigue of Metallic Materials- 2173585 . . . . .  | 341 |
| Schwingungstechnisches Praktikum- 2161241 . . . . .   | 342 |
| Safety Engineering- 2117061 . . . . .   | 343 |
| - 23109 . . . . .   | 344 |
| Simulation of Coupled Systems- 2114095 . . . . .  | 345 |
| Simulation of production systems and processes- 2149605 . . . . .                               | 346 |
| Scaling in fluid dynamics- 2154044 . . . . .  | 348 |
| Theory of Stability- 2163113 . . . . .  | 349 |
| Control Technology- 2150683 . . . . .   | 350 |
| Strategic Product Planing- 2146193 . . . . .  | 352 |
| Flows in rotating systems- 2154407 . . . . .  | 353 |
| Flows with chemical reactions- 2153406 . . . . .  | 354 |
| Flows and Heat Transfer in Energy Technology- 2189910 . . . . .                                 | 355 |
| Structural and phase analysis- 2125763 . . . . .  | 356 |
| Structural Ceramics- 2126775 . . . . .  | 357 |
| Superconducting Materials for Energy Applications- 23682 . . . . .                              | 358 |
| Superhard Thin Film Materials- 2177618 . . . . .  | 359 |
| Supply chain management- 2117062 . . . . .  | 360 |
| Sustainable Product Engineering- 2146192 . . . . .  | 361 |
| Systematic Materials Selection- 2174576 . . . . .   | 362 |
| Systems and Software Engineering- 23605 . . . . .   | 363 |
| Theoretical Description of Mechatronic Systems- 2161117 . . . . .                               | 365 |
| Technical Acoustics- 2158107 . . . . .  | 366 |
| Computer Engineering- 2106002 . . . . .   | 367 |
| Integrated Information Systems for engineers- 2121001 . . . . .                                 | 368 |
| Vibration Theory- 2161212 . . . . .   | 369 |
| Technical Design in Product Development- 2146179 . . . . .                                      | 371 |
| Technology of steel components- 2174579 . . . . .   | 372 |
| Ten lectures on turbulence- 2189904 . . . . .   | 373 |
| Materials under high thermal or neutron loads- 2194650 . . . . .                                | 374 |
| Computational methods for the heat protection of a full vehicle- 2157445 . . . . .              | 375 |
| Thermal Solar Energy- 2169472 . . . . .   | 376 |
| Thermal Turbomachines I- 2169453 . . . . .  | 378 |
| Thermal Turbomachines II- 2170476 . . . . .   | 379 |
| Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises)- 2193002 | 380 |
| Tractors- 2113080 . . . . .   | 381 |
| Tribology- 2181114 . . . . .  | 382 |
| Turbine and compressor Design- 2169462 . . . . .  | 383 |
| Turbo Jet Engines- 2170478 . . . . .  | 384 |
| Tutorial for Heat Transfer in Nuclear Reactors- 2189901 . . . . .                               | 385 |
| Metal Forming- 2150681 . . . . .  | 386 |
| Vacuum and Tritium Technology- 2190499 . . . . .  | 388 |
| Combustion diagnostics- 2167048 . . . . .   | 389 |
| Behaviour Generation for Vehicles- 2138336 . . . . .  | 390 |
| Failure of Structural Materials: Fatigue and Creep- 2181715 . . . . .                           | 391 |
| Failure of structural materials: deformation and fracture- 2181711 . . . . .                    | 392 |
| Gear Cutting Technology- 2149655 . . . . .  | 394 |
| Virtual Engineering (Specific Topics)- 3122031 . . . . .  | 396 |
| Virtual Engineering I- 2121352 . . . . .  | 397 |
| Virtual Engineering II- 2122378 . . . . .   | 398 |
| Heat and mass transfer- 2165512 . . . . .   | 399 |
| Heatpumps- 2166534 . . . . .  | 400 |
| Heat Transfer in Nuclear Reactors- 2189907 . . . . .  | 401 |
| Probability Theory and Statistics- 0186000 . . . . .  | 402 |
| Hydrogen Technologies- 2170495 . . . . .  | 403 |

|   |            |
|---|------------|
| Wave Propagation- 2161219                                       | 404        |
| Material Analysis- 2174586                                      | 405        |
| Materials for Lightweight Construction- 2174574                 | 406        |
| Materials modelling: dislocation based plasticity- 2182740      | 407        |
| Wind and Hydropower- 2157451                                    | 408        |
| Scientific computing for Engineers- 2181738                     | 409        |
| Two-Phase Flow and Heat Transfer- 2169470                       | 410        |
| <b>5 Major Fields</b>   | <b>411</b> |
| SP 01: Advanced Mechatronics                                    | 412        |
| SP 02: Powertrain Systems                                       | 414        |
| SP 03: Human Factors Engineering                                | 415        |
| SP 04: Automation Technology                                    | 416        |
| SP 05: Calculation Methods in Mechanical Engineering            | 417        |
| SP 06: Computational Mechanics                                  | 419        |
| SP 08: Dynamics and Vibration Theory                            | 421        |
| SP 09: Dynamic Machine Models                                   | 422        |
| SP 10: Engineering Design                                       | 423        |
| SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics          | 425        |
| SP 12: Automotive Technology                                    | 426        |
| SP 15: Fundamentals of Energy Technology                        | 428        |
| SP 16: Industrial Engineering                                   | 429        |
| SP 18: Information Technology                                   | 430        |
| SP 19: Information Technology of Logistic Systems               | 431        |
| SP 20: Integrated Product Development                           | 432        |
| SP 21: Nuclear Energy   | 433        |
| SP 22: Cognitive Technical Systems                              | 434        |
| SP 23: Power Plant Technology                                   | 435        |
| SP 24: Energy Converting Engines                                | 437        |
| SP 25: Lightweight Construction                                 | 438        |
| SP 26: Materials Science and Engineering                        | 440        |
| SP 27: Modeling and Simulation in Energy- and Fluid Engineering | 442        |
| SP 28: Lifecycle Engineering                                    | 443        |
| SP 29: Logistics and Material Flow Theory                       | 444        |
| SP 30: Applied Mechanics  | 445        |
| SP 31: Mechatronics   | 446        |
| SP 32: Medical Technology                                       | 448        |
| SP 33: Microsystem Technology                                   | 450        |
| SP 34: Mobile Machines  | 451        |
| SP 35: Modeling and Simulation                                  | 452        |
| SP 36: Polymer Engineering                                      | 454        |
| SP 37: Production Management                                    | 455        |
| SP 39: Production Technology                                    | 456        |
| SP 40: Robotics   | 458        |
| SP 41: Fluid Mechanics  | 460        |
| SP 43: Technical Ceramics and Powder Materials                  | 462        |
| SP 44: Technical Logistics                                      | 463        |
| SP 45: Engineering Thermodynamics                               | 464        |
| SP 46: Thermal Turbomachines                                    | 465        |
| SP 47: Tribology  | 466        |
| SP 49: Reliability in Mechanical Engineering                    | 467        |
| SP 50: Rail System Technology                                   | 469        |
| SP 51: Development of innovative appliances and power tools     | 470        |
| SP 53: Fusion Technology  | 471        |
| SP 54: Microactuators and Microsensors                          | 472        |
| SP 55: Energy Technology for Buildings                          | 473        |
| SP 56: Advanced Materials Modelling                             | 474        |
|   | 475        |

|   |            |
|---|------------|
| <b>6 Courses of the Major Fields</b>  | <b>477</b> |
| 6.1 All Courses   | 477        |
| Analysis of Exhaust Gas und Lubricating Oil in Combustion Engines- 2134150          | 477        |
| Adaptive Control Systems- 2105012   | 478        |
| Adsorption Technology for Heat Transformation - Systems and Applications- 2158230   | 479        |
| Adsorption Technology for Heat Transformation – Materials and Principles- 2157231   | 480        |
| Aerodynamics- 2154420   | 481        |
| Aerothermodynamics- 2154436   | 482        |
| Actuators and sensors in nanotechnology- 2141866                                    | 483        |
| Actual topics of BioMEMS- 2143873   | 484        |
| Analysis and Design of Multisensor Systems- 23064                                   | 485        |
| Low Temperature Technology- 2158112   | 486        |
| Applied Tribology in Industrial Product Development- 2145181                        | 487        |
| Applied Materials Modelling- 2181614  | 488        |
| Drive Train of Mobile Machines- 2113077   | 489        |
| Drive Systems and Possibilities to Increase Efficiency- 2133112                     | 490        |
| Powertrain Systems Technology A: Automotive Systems- 2146180                        | 491        |
| Powertrain Systems Technology B: Stationary Machinery- 2145150                      | 492        |
| Application of technical logistics in modern crane systems- 2117064                 | 493        |
| Application of technical logistics in sorting- and distribution technology- 2118089 | 494        |
| Application of advanced programming languages in mechanical engineering- 2182735    | 495        |
| Human Factors Engineering I- 2109035  | 496        |
| Human Factors Engineering II- 2109036   | 498        |
| Human Factors Lab- 2109033  | 499        |
| Atomistic simulations and molecular dynamics- 2181740                               | 500        |
| Constitution and Properties of Wear resistant materials- 2194643                    | 501        |
| Constitution and Properties of Protective Coatings- 2177601                         | 502        |
| Selected Applications of Technical Logistics- 2118087                               | 503        |
| Selected Applications of Technical Logistics and Project- 2118088                   | 504        |
| Selected Topics in Aeronautics and Astronautics I- 2170454                          | 505        |
| Selected Topics in Aeronautics and Astronautics II- 2169486                         | 506        |
| Selected Topics on Optics and Microoptics for Mechanical Engineers- 2143892         | 507        |
| Selected chapters of the combustion fundamentals- 2167541                           | 508        |
| Selected Problems of Applied Reactor Physics and Exercises- 2190411                 | 509        |
| Design of combustion chamber in gas turbines (Project)- 22509                       | 510        |
| Design of highly stresses components- 2181745                                       | 511        |
| Design and Development of Mobile Machines- 2113079                                  | 512        |
| Dimensioning and Optimization of Power Train System- 2146208                        | 513        |
| Automated Manufacturing Systems- 2150904  | 514        |
| Automation Systems- 2106005   | 516        |
| Automotive Engineering I- 2113809   | 517        |
| Automotive Engineering II- 2114855  | 518        |
| Rail System Technology- 2115919   | 519        |
| Operation- 6234801  | 520        |
| Fuels and Lubricants for Combustion Engines- 2133108                                | 521        |
| Operation Systems and Track Guided Infrastructure Capacity- 6234804                 | 522        |
| Evaluation of welded joints- 2181730  | 523        |
| Medical Imaging Techniques I - 23261  | 524        |
| Medical Imaging Techniques II- 23262  | 525        |
| Bioelectric Signals - 23264   | 526        |
| Biomedical Measurement Techniques I- 23269  | 527        |
| Biomedical Measurement Techniques II- 23270   | 528        |
| BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I- 2141864       | 529        |
| BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II- 2142883      | 530        |
| BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III- 2142879     | 531        |
| Bionics for Engineers and Natural Scientists- 2142140                               | 532        |
| BUS-Controls- 2114092   | 533        |
| CATIA CAD training course- 2123358  | 534        |

|   |     |
|---|-----|
| CAD-NX training course- 2123357   | 535 |
| CAE-Workshop- 2147175   | 536 |
| CATIA advanced- 2123380   | 537 |
| CFD for Power Engineering- 2130910  | 538 |
| CFD-Lab using Open Foam- 2169459  | 539 |
| Computational Intelligence I- 2106004   | 541 |
| Computational Intelligence II- 2105015  | 542 |
| Computational Intelligence III- 2106020   | 543 |
| Railways in the Transportation Market- 2114914  | 544 |
| Finite Difference Methods for numerical solution of thermal and fluid dynamical problems- 2153405 | 545 |
| Digital Control- 2137309  | 546 |
| Designing with numerical methods in product development- 2161229                                  | 547 |
| Designing with composites- 2162255  | 548 |
| Dynamics of mechanical Systems with tribological Contacts- 2162207                                | 549 |
| Dynamics of the Automotive Drive Train- 2163111   | 550 |
| Introduction to the Finite Element Method- 2162282  | 551 |
| Introduction to Nuclear Energy- 2189903   | 552 |
| Introduction to Nuclear Engineering- 2130974  | 553 |
| Introduction to Theory of Materials- 2182732  | 554 |
| Introduction to the Mechanics of Composite Materials- 2178734                                     | 555 |
| Introduction into Mechatronics- 2105011   | 556 |
| Introduction into the multi-body dynamics- 2162235  | 557 |
| Introduction to modeling of aerospace systems- 2154430  | 558 |
| Introduction to numerical mechanics- 2161226  | 559 |
| Introduction to numerical fluid dynamics- 2157444   | 560 |
| Wave propagation- 2161216   | 561 |
| Introduction to Nonlinear Vibrations- 2162247   | 562 |
| Electric Rail Vehicles- 2114346   | 564 |
| Elements of Technical Logistics- 2117096  | 565 |
| Elements of Technical Logistics and Project- 2117097  | 566 |
| - 2157202   | 567 |
| Energy efficient intralogistic systems- 2117500   | 568 |
| Energy Systems I: Renewable Energy- 2129901   | 569 |
| Energy systems II: Reactor Technology- 2130926  | 570 |
| Energy Systems II: Nuclear Energy and Reactor Technology- 2130921                                 | 571 |
| Energy Conversion and Increased Efficiency in Internal Combustion Engines- 2133121                | 572 |
| Design Project Machine Tools and Industrial Handling- 2149903                                     | 573 |
| Organ support systems- 2106008  | 575 |
| Experimental Dynamics- 2162225  | 576 |
| Experimental Fluid Mechanics- 2154446   | 577 |
| Metallographic Lab Class- 2175590   | 578 |
| Welding Lab Course, in groupes- 2173560   | 579 |
| Handling Characteristics of Motor Vehicles I- 2113807   | 580 |
| Handling Characteristics of Motor Vehicles II- 2114838  | 581 |
| Vehicle Comfort and Acoustics I- 2113806  | 582 |
| Vehicle Comfort and Acoustics II- 2114825   | 583 |
| Introduction to Automotive Lightweight Technology- 2113102  | 584 |
| Vehicle Mechatronics I- 2113816   | 585 |
| Basics and Methods for Integration of Tires and Vehicles- 2114845                                 | 586 |
| Automotive Vision- 2138340  | 587 |
| Composites for Lightweight Design- 2114053  | 588 |
| FEM Workshop – constitutive laws- 2183716   | 589 |
| Fabrication Processes in Microsystem Technology- 2143882  | 590 |
| Manufacturing Technology- 2149657   | 591 |
| Solid State Reactions and Kinetics of Phase Transformations (with exercises)- 2193003             | 593 |
| Finite Element Workshop- 2182731  | 594 |
| Finite Volume Methods for Fluid Flow- 2154431   | 595 |
| Fluid-Structure-Interaction- 2154401  | 596 |

|   |     |
|---|-----|
| Fluid Mechanics of Turbulent Flows- 6221806 . . . . .   | 597 |
| Fluid Technology- 2114093 . . . . .   | 598 |
| Functional Ceramics- 2126784 . . . . .  | 599 |
| Fusion Technology A- 2169483 . . . . .  | 600 |
| Fusion Technology B- 2190492 . . . . .  | 601 |
| Combined Cycle Power Plants- 2170490 . . . . .  | 602 |
| - 2154200 . . . . .   | 603 |
| Gas Engines- 2134141 . . . . .  | 604 |
| Building- and Environmental Aerodynamics- 19228 . . . . .   | 605 |
| Human brain and central nervous system: anatomy, information transfer, signal processing, neuro-<br>physiology and therapy- 24139 / 24678 . . . . . | 606 |
| Appliance and Power Tool Design- 2145164 . . . . .  | 607 |
| Global vehicle evaluation within virtual road test- 2114850 . . . . .   | 608 |
| Foundry Technology- 2174575 . . . . .   | 609 |
| Global Production and Logistics - Part 1: Global Production- 2149610 . . . . .  | 610 |
| Global Production and Logistics - Part 2: Global Logistics- 2149600 . . . . .   | 612 |
| Size effects in micro and nanostructures materials- 2181744 . . . . .   | 614 |
| Fundamentals of Energy Technology- 2130927 . . . . .  | 615 |
| Automotive Engineering I- 2113805 . . . . .   | 616 |
| Automotive Engineering II- 2114835 . . . . .  | 617 |
| Grundlagen der Herstellungsverfahren der Keramik und Pulvermetallurgie- 2193010 . . . . .   | 618 |
| Fundamentals of catalytic exhaust gas aftertreatment- 2134138 . . . . .   | 619 |
| Principles of Medicine for Engineers- 2105992 . . . . .   | 620 |
| Introduction to Microsystem Technology I- 2141861 . . . . .   | 621 |
| Introduction to Microsystem Technology II- 2142874 . . . . .  | 622 |
| Foundations of nonlinear continuum mechanics- 2181720 . . . . .   | 623 |
| Fundamentals of reactor safety for the operation and dismantling of nuclear power plants- 2190465 . . . . .   | 624 |
| Fundamentals of X-ray Optics I- 2141007 . . . . .   | 625 |
| Basics of Technical Logistics- 2117095 . . . . .  | 626 |
| Fundamentals of Combustion I- 2165515 . . . . .   | 627 |
| Fundamentals of combustion II- 2166538 . . . . .  | 628 |
| Fundamentals of Combustion Engines I- 2133103 . . . . .   | 629 |
| Fundamentals of Combustion Engines II- 2134131 . . . . .  | 630 |
| Optical Flow Measurement: Fundamentals and Applications- 2153410 . . . . .  | 631 |
| Fundamentals for Design of Motor-Vehicles Bodies I- 2113814 . . . . .   | 632 |
| Fundamentals for Design of Motor-Vehicles Bodies II- 2114840 . . . . .  | 633 |
| Fundamentals in the Development of Commercial Vehicles I- 2113812 . . . . .   | 634 |
| Fundamentals in the Development of Commercial Vehicles II- 2114844 . . . . .  | 635 |
| Fundamentals of Automobile Development I- 2113810 . . . . .   | 636 |
| Fundamentals of Automobile Development II- 2114842 . . . . .  | 637 |
| High Performance Computing- 2183721 . . . . .   | 638 |
| High Temperature Structural Materials- 2174600 . . . . .  | 639 |
| Advanced Methods in Strength of Materials- 2161252 . . . . .  | 640 |
| Hybrid and Electric Vehicles- 23321 . . . . .   | 641 |
| Hydraulic Fluid Machinery I (Basics)- 2157432 . . . . .   | 643 |
| Hydraulic Fluid Machinery II- 2158105 . . . . .   | 644 |
| Hydrodynamic Stability: From Order to Chaos- 2154437 . . . . .  | 645 |
| Industrial aerodynamics- 2153425 . . . . .  | 646 |
| Introduction to Industrial Production Economics- 2109042 . . . . .  | 647 |
| Occupational Safety and Environmental Protection (in German)- 2110037 . . . . .   | 648 |
| Information Engineering- 2122014 . . . . .  | 650 |
| Information Systems in Logistics and Supply Chain Management- 2118094 . . . . .   | 651 |
| Information Processing in Mechatronic Systems- 2105022 . . . . .  | 652 |
| Information Processing in Sensor Networks- 24102 . . . . .  | 653 |
| Innovation Workshop: Mobility concepts for the year 2050- 2115916 . . . . .   | 654 |
| Innovative Nuclear Systems- 2130973 . . . . .   | 655 |
| Integrative Strategies in Production and Development of High Performance Cars- 2150601 . . . . .  | 656 |
| Integrated measurement systems for fluid mechanics applications- 2171486 . . . . .  | 657 |

|   |     |
|---|-----|
| Integrated Product Development- 2145156   | 658 |
| Integrated production planning- 2150660   | 659 |
| Introduction to Neutron Cross Section Theory and Nuclear Data Generation- 2190490             | 661 |
| IT-Fundamentals of Logistics- 2118183   | 662 |
| Introduction to Ceramics- 2125757   | 664 |
| Ceramics Processing- 2126730  | 665 |
| Nuclear Power Plant Technology- 2170460   | 666 |
| Cognitive Automobiles - Laboratory- 2138341   | 668 |
| Cognitive Systems- 24572  | 669 |
| Coal fired power plants- 2169461  | 670 |
| Design with Plastics- 2174571   | 671 |
| Lightweight Engineering Design - 2146190  | 672 |
| Vibration of continuous systems- 2161214  | 673 |
| Power and Heat economics- 2169452   | 674 |
| Motor Vehicle Laboratory- 2115808   | 675 |
| Cooling of thermally high loaded gas turbine components- 2170463                              | 676 |
| Warehousing and distribution systems- 2118097   | 677 |
| Laser in automotive engineering- 2182642  | 679 |
| Leadership and Product Development- 2145184   | 680 |
| Laboratory Exercise in Energy Technology- 2171487   | 681 |
| Logistics - organisation, design and control of logistic systems- 2118078                     | 682 |
| Automotive Logistics- 2118085   | 683 |
| Airport logistics- 2117056  | 684 |
| Localization of Mobile Agents- 24613  | 685 |
| Machine Vision- 2137308   | 686 |
| Magnet Technology of Fusion Reactors- 2190496   | 687 |
| Magnetohydrodynamics- 2153429   | 688 |
| Leadership and Conflict Management (in German)- 2110017                                       | 689 |
| Machine Dynamics- 2161224   | 691 |
| Machine Dynamics II- 2162220  | 692 |
| Material flow in logistic systems- 2117051  | 693 |
| Materials and Processes for Body Lightweight Construction in the Automotive Industry- 2149669 | 694 |
| Mathematical Foundation for Computational Mechanics- 2162240                                  | 695 |
| Mathematical Methods in Dynamics- 2161206   | 696 |
| Mathematical Methods in Strength of Materials- 2161254  | 697 |
| Mathematical methods of vibration theory- 2162241   | 698 |
| Mathematical Methods in Fluid Mechanics- 2154432  | 699 |
| Mathematical Methods in Structural Mechanics- 2162280   | 700 |
| Mathematical models and methods in combustion theory- 2165525                                 | 701 |
| Mathematical models and methods for Production Systems- 2117059                               | 702 |
| Mechanics of laminated composites- 2161983  | 704 |
| Mechanics and Strengths of Polymers- 2173580  | 705 |
| Mechanics in Microtechnology- 2181710   | 706 |
| Laboratory mechatronics- 2105014  | 707 |
| Human-Machine-Interaction- 24659  | 708 |
| Measurement Technology- 23105   | 709 |
| Measurement technique for fluid mechanics- 2190913  | 710 |
| Measurement II- 2138326   | 711 |
| Analysis tools for combustion diagnostics- 2134134  | 712 |
| Methodic Development of Mechatronic systems- 2145180  | 713 |
| Methodical Design of Composite Structures- 2114101  | 714 |
| Microenergy Technologies- 2142897   | 715 |
| Microoptics and Lithography- 2142884  | 716 |
| Microactuators- 2142881   | 717 |
| Microstructure characterization and modelling- 2161251  | 718 |
| Modelling of Microstructures- 2183702   | 719 |
| Mobile Machines- 2114073  | 721 |
| Model based Application Methods- 2134139  | 722 |

|   |     |
|---|-----|
| Modeling of Thermodynamical Processes- 2167523                                  | 723 |
| Modelling and Simulation- 2183703   | 724 |
| - 2158206   | 725 |
| Modern Control Concepts I- 2105024  | 726 |
| Engine Laboratory- 2134001  | 727 |
| Engine measurement techniques- 2134137  | 728 |
| Multilingual Human-Machine Communication- 24600                                 | 729 |
| Nanotechnology for Engineers and Natural Scientists- 2142861                    | 730 |
| Nanotechnology with Clusterbeams- 2143876                                       | 731 |
| Nanotribology and -Mechanics- 2181712   | 732 |
| Novel actuators and sensors- 2141865  | 733 |
| Neutron physics of fusion reactors- 2189473                                     | 734 |
| Nonlinear Continuum Mechanics- 2162344  | 735 |
| Nuklear Medicine and Nuklear Medicine Measurement Technics I- 23289             | 736 |
| Numerical Mathematics- 01874  | 737 |
| Numerical mechanics for industrial applications- 2162298                        | 738 |
| Computational Methods in Fluid Mechanics- 2157441                               | 739 |
| Numerical Modeling of Multiphase Flows- 2130934                                 | 740 |
| Numerical simulation of reacting two phase flows- 2169458                       | 741 |
| Numerical Simulation of Turbulent Flows- 2154449                                | 742 |
| Numerical Fluid Mechanics with MATLAB- 2154409                                  | 743 |
| Intellectual Property Rights and Strategies in Industrial Companies- 2147161    | 744 |
| Photovoltaics- 23737  | 745 |
| - 2189906   | 746 |
| Planning of Assembly Systems (in German)- 2109034                               | 747 |
| Multi-scale Plasticity- 2181750   | 749 |
| PLM for Product Development in Mechatronics- 2122376                            | 750 |
| PLM in the Manufacturing Industry- 2121366                                      | 751 |
| Polymer Engineering I- 2173590  | 752 |
| Polymer Engineering II- 2174596   | 753 |
| Polymers in MEMS A: Chemistry, Synthesis and Applications- 2141853              | 754 |
| Polymers in MEMS B: Physics, Microstructuring and Applications- 2141854         | 756 |
| - 2142855   | 758 |
| - 2142856   | 760 |
| Laboratory "Laser Materials Processing"- 2183640                                | 761 |
| Lab Computer-aided methods for measurement and control- 2137306                 | 762 |
| Practical Course Technical Ceramics- 2125751                                    | 763 |
| Introduction to Microsystem Technology - Practical Course- 2143875              | 764 |
| Product Lifecycle Management- 2121350   | 765 |
| Product, Process and Resource Integration in the Automotive Industry- 2123364   | 767 |
| Production Management I- 2109028  | 768 |
| Production Management II- 2110028   | 769 |
| Production Planning and Control- 2110032  | 770 |
| Production Techniques Laboratory- 2110678                                       | 772 |
| Production Technology and Management in Automotive - 2149001                    | 774 |
| Productivity Management in Production Systems- 2110046                          | 776 |
| Project Workshop: Automotive Engineering- 2115817                               | 778 |
| Project Mikro Manufacturing: Design and Manufacturing of Micro Systems- 2149680 | 779 |
| Development of Oil-Hydraulic Powertrain Systems- 2113072                        | 780 |
| Project Management in Rail Industry- 2115995                                    | 781 |
| Project management in Global Product Engineering Structures- 2145182            | 782 |
| Process Simulation in Forming Operations- 2161501                               | 783 |
| Advanced powder metals- 2126749   | 784 |
| Quality Management- 2149667   | 785 |
| Nuclear Fuel Cycle and Radiochemistry- 5010                                     | 787 |
| Reactor Safety I: Fundamentals- 2189465   | 788 |
| Computational Dynamics- 2162246   | 789 |
| Computational Vehicle Dynamics- 2162256   | 790 |

|   |     |
|---|-----|
| Computerized Multibody Dynamics- 2162216 . . . . .  | 791 |
| Computer Integrated Planning of New Products- 2122387 . . . . .   | 792 |
| Computational Mechanics I- 2161250 . . . . .  | 793 |
| Computational Mechanics II- 2162296 . . . . .   | 794 |
| Reduction methods for the modeling and the simulation of combustion processes- 2166543 . . . . .          | 795 |
| Robotics I – Introduction to robotics- 24152 . . . . .  | 796 |
| Robotics II - Learning and planning robots- 24712 . . . . .   | 797 |
| Robotik III - Sensors in Robotics- 24635 . . . . .  | 798 |
| Medical Robotics- 24681 . . . . .   | 799 |
| Decommissioning of Nuclear Facilities I- 19435 . . . . .  | 800 |
| Rail Vehicle Technology- 2115996 . . . . .  | 801 |
| Welding Technology I- 2173565 . . . . .   | 802 |
| Welding Technology II- 2174570 . . . . .  | 804 |
| Fatigue of Metallic Materials- 2173585 . . . . .  | 806 |
| Schwingungstechnisches Praktikum- 2161241 . . . . .   | 807 |
| - 5012053 . . . . .   | 808 |
| Safety Engineering- 2117061 . . . . .   | 809 |
| Signals and Systems- 23109 . . . . .  | 810 |
| Simulation of Coupled Systems- 2114095 . . . . .  | 811 |
| Simulation in product development process- 2185264 . . . . .  | 812 |
| Simulation of production systems and processes- 2149605 . . . . .   | 813 |
| Simulation Aided Management- 2109032 . . . . .  | 815 |
| Simulator Exercises Combined Cycle Power Plants- 2170491 . . . . .  | 817 |
| Scaling in fluid dynamics- 2154044 . . . . .  | 818 |
| Mechatronic Softwaretools- 2161217 . . . . .  | 819 |
| Track Guided Transport Systems - Technical Design and Components- 6234701 . . . . .                       | 820 |
| Theory of Stability- 2163113 . . . . .  | 821 |
| Control Technology- 2150683 . . . . .   | 822 |
| Radiation Protection I: Ionising Radiation- 23271 . . . . .   | 824 |
| Strategic Product Planing- 2146193 . . . . .  | 825 |
| Flows in rotating systems- 2154407 . . . . .  | 826 |
| Flows with chemical reactions- 2153406 . . . . .  | 827 |
| Flows and Heat Transfer in Energy Technology- 2189910 . . . . .   | 828 |
| Flow Simulations with OpenFOAM- 2154445 . . . . .   | 829 |
| Structural and phase analysis- 2125763 . . . . .  | 830 |
| Structural Ceramics- 2126775 . . . . .  | 831 |
| Superhard Thin Film Materials- 2177618 . . . . .  | 832 |
| Supply chain management- 2117062 . . . . .  | 833 |
| Sustainable Product Engineering- 2146192 . . . . .  | 834 |
| System Integration in Micro- and Nanotechnology- 2106033 . . . . .  | 835 |
| Technical Acoustics- 2158107 . . . . .  | 836 |
| - 2157200 . . . . .   | 837 |
| - 2158201 . . . . .   | 838 |
| Computer Engineering- 2106002 . . . . .   | 839 |
| Vibration Theory- 2161212 . . . . .   | 840 |
| Technical Design in Product Development- 2146179 . . . . .  | 841 |
| Technology of steel components- 2174579 . . . . .   | 842 |
| Ten lectures on turbulence- 2189904 . . . . .   | 843 |
| Materials under high thermal or neutron loads- 2194650 . . . . .  | 844 |
| Computational methods for the heat protection of a full vehicle- 2157445 . . . . .                        | 845 |
| Thermal Solar Energy- 2169472 . . . . .   | 846 |
| Thermal Turbomachines I- 2169453 . . . . .  | 848 |
| Thermal Turbomachines II- 2170476 . . . . .   | 849 |
| Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises)- 2193002 . . . . . | 850 |
| Thin film and small-scale mechanical behavior- 2178123 . . . . .  | 851 |
| Tractors- 2113080 . . . . .   | 852 |
| Tribology- 2181114 . . . . .  | 853 |
| Turbine and compressor Design- 2169462 . . . . .  | 854 |

|  |            |
|--|------------|
| Turbo Jet Engines- 2170478 . . . . .   | 855        |
| Tutorial for Heat Transfer in Nuclear Reactors- 2189901 . . . . .            | 856        |
| Metal Forming- 2150681 . . . . .   | 857        |
| Vehicle Ride Comfort & Acoustics I- 2114856 . . . . .                        | 859        |
| Vehicle Ride Comfort & Acoustics II- 2114857 . . . . .                       | 860        |
| Combustion diagnostics- 2167048 . . . . .                                    | 861        |
| Behaviour Generation for Vehicles- 2138336 . . . . .                         | 862        |
| Failure of Structural Materials: Fatigue and Creep- 2181715 . . . . .        | 863        |
| Failure of structural materials: deformation and fracture- 2181711 . . . . . | 865        |
| Gear Cutting Technology- 2149655 . . . . .                                   | 867        |
| Virtual Engineering I- 2121352 . . . . .                                     | 869        |
| Virtual Engineering II- 2122378 . . . . .                                    | 870        |
| Virtual Reality Laboratory- 2123375 . . . . .                                | 871        |
| Heatpumps- 2166534 . . . . .   | 872        |
| Heat Transfer in Nuclear Reactors- 2189907 . . . . .                         | 873        |
| Hydrogen Technologies- 2170495 . . . . .                                     | 874        |
| Wave Propagation- 2161219 . . . . .  | 875        |
| Material Analysis- 2174586 . . . . .   | 876        |
| Materials for Lightweight Construction- 2174574 . . . . .                    | 877        |
| Materials Science and Engineering III- 2173553 . . . . .                     | 878        |
| Materials modelling: dislocation based plasticity- 2182740 . . . . .         | 879        |
| Machine Tools and Industrial Handling- 2149902 . . . . .                     | 880        |
| Wind and Hydropower- 2157451 . . . . .                                       | 882        |
| Windpower- 2157381 . . . . .   | 883        |
| Scientific computing for Engineers- 2181738 . . . . .                        | 884        |
| Two-Phase Flow and Heat Transfer- 2169470 . . . . .                          | 885        |
| <b>7 Appendix: Examination regulation</b>                                    | <b>886</b> |
| <b>Index</b>   | <b>907</b> |

## Studienplan der Fakultät Maschinenbau für den Bachelor- und Masterstudiengang Maschinenbau

Fassung vom 16. Juli 2014

### Inhaltsverzeichnis

|     |   |    |
|-----|---|----|
| 0   | Abkürzungsverzeichnis .....   | 2  |
| 1   | Studienpläne, Module und Prüfungen .....  | 3  |
| 1.1 | Prüfungsmodalitäten .....   | 3  |
| 1.2 | Module des Bachelorstudiums „B.Sc.“ .....   | 3  |
| 1.3 | Studienplan des 1. Abschnitts des Bachelorstudiums „B.Sc.“ .....  | 5  |
| 1.4 | Studienplan des 2. Abschnitts des Bachelorstudiums „B.Sc.“ .....  | 5  |
| 1.5 | Masterstudium mit Vertiefungsrichtungen .....   | 6  |
| 2   | Zugelassene Wahl- und Wahlpflichtfächer .....   | 7  |
| 2.1 | Wahlpflichtfächer im Bachelor- und Masterstudiengang .....  | 7  |
| 2.2 | Mathematische Methoden im Masterstudiengang .....   | 8  |
| 2.3 | Wahlfach aus dem Bereich Naturwissenschaften/Informatik/Elektrotechnik im<br>Masterstudiengang .....                | 8  |
| 2.4 | Wahlfach aus dem Bereich Wirtschaft/Recht im Masterstudiengang .....  | 9  |
| 2.5 | Wahlfach im Masterstudiengang .....   | 9  |
| 3   | Fachpraktikum im Masterstudiengang .....  | 9  |
| 4   | Berufspraktikum .....   | 10 |
| 4.1 | Inhalt und Durchführung des Berufspraktikums .....  | 10 |
| 4.2 | Anerkennung des Berufspraktikums .....  | 11 |
| 4.3 | Sonderbestimmungen zur Anerkennung .....  | 11 |
| 5   | Bachelor- und Masterarbeit .....  | 12 |
| 6   | Schwerpunkte im Bachelor- und im Masterstudiengang .....  | 13 |
| 6.1 | Zuordnung der Schwerpunkte zum Bachelorstudiengang und zu den<br>Vertiefungsrichtungen des Masterstudiengangs ..... | 13 |
| 6.2 | Wahlmöglichkeiten für den Schwerpunkt im Bachelorstudiengang .....  | 14 |
| 6.3 | Wahlmöglichkeiten in den einzelnen Schwerpunkten im Masterstudiengang .....   | 15 |
| 6.4 | Schwerpunkte im Bachelor- und im Masterstudiengang Maschinenbau .....   | 15 |
| 7   | Änderungshistorie (ab 29.10.2008) .....   | 17 |

## 0 Abkürzungsverzeichnis

|                        |  |  |
|------------------------|--|--|
| Vertiefungsrichtungen: | MSc<br>E+U<br>FzgT<br>M+M<br>PEK<br>PT<br>ThM<br>W+S | Allgemeiner Maschinenbau<br>Energie- und Umwelttechnik<br>Fahrzeugtechnik<br>Mechatronik und Mikrosystemtechnik<br>Produktentwicklung und Konstruktion<br>Produktionstechnik<br>Theoretischer Maschinenbau<br>Werkstoffe und Strukturen für Hochleistungssysteme |
| Fakultäten:            | mach<br>inf<br>etit<br>ciw<br>phys<br>wiwi           | Fakultät für Maschinenbau<br>Fakultät für Informatik<br>Fakultät für Elektrotechnik und Informationstechnik<br>Fakultät für Chemieingenieurwesen und Verfahrenstechnik<br>Fakultät für Physik<br>Fakultät für Wirtschaftsingenieurwesen                          |
| Semester:              | WS<br>SS<br>ww                                       | Wintersemester<br>Sommersemester<br>wahlweise (Angebot im Sommer- und Wintersemester)  |
| Schwerpunkte:          | Kat<br>K, KP<br>E<br>EM                              | Kategorie der Fächer im Schwerpunkt<br>Kernmodulfach, ggf. Pflicht im Schwerpunkt<br>Ergänzungsfach im Schwerpunkt<br>Ergänzungsfach ist nur im Masterstudiengang wählbar  |
| Leistungen:            | V<br>Ü<br>P<br>LP<br>mPr<br>sPr<br>Gew               | Vorlesung<br>Übung<br>Praktikum<br>Leistungspunkte<br>mündliche Prüfung<br>schriftliche Prüfung<br>Gewichtung einer Prüfungsleistung im Modul bzw. in der Gesamtnote   |
| Sonstiges:             | B.Sc.<br>M.Sc.<br>SPO<br>SWS<br>WPF<br>w<br>p        | Studiengang Bachelor of Science<br>Studiengang Master of Science<br>Studien- und Prüfungsordnung<br>Semesterwochenstunden<br>Wahlpflichtfach<br>wählbar<br>verpflichtend   |

## 1 Studienpläne, Module und Prüfungen

Die Angabe der Leistungspunkte (LP) erfolgt gemäß dem „European Credit Transfer and Accumulation System“ (ECTS) und basiert auf dem von den Studierenden zu absolvierenden Arbeitspensum.

### 1.1 Prüfungsmodalitäten

In jedem Semester sind für schriftliche Prüfungen mindestens ein Prüfungstermin und für mündliche Prüfungen mindestens zwei Termine anzubieten. Prüfungstermine sowie Termine, zu denen die Meldung zu den Prüfungen spätestens erfolgen muss, werden von der Prüfungskommission festgelegt. Die Meldung für die Fachprüfungen erfolgt in der Regel mindestens eine Woche vor der Prüfung. Melde- und Prüfungstermine werden rechtzeitig durch Anschlag bekanntgegeben, bei schriftlichen Prüfungen mindestens 6 Wochen vor der Prüfung.

Über Hilfsmittel, die bei einer Prüfung benutzt werden dürfen, entscheidet der Prüfer. Eine Liste der zugelassenen Hilfsmittel ist gleichzeitig mit der Ankündigung des Prüfungstermins bekanntzugeben.

Für die Erfolgskontrollen in den Schwerpunkt-Modulen gelten folgende Regeln:

Die Fachprüfungen sind grundsätzlich mündlich abzunehmen, bei unvertretbar hohem Prüfungsaufwand kann eine mündlich durchzuführende Prüfung auch schriftlich abgenommen werden.

Die Prüfung im Kernbereich eines Schwerpunkts ist an einem einzigen Termin anzulegen. Erfolgskontrollen im Ergänzungsbereich können separat erfolgen. Bei mündlichen Prüfungen in Schwerpunkten bzw. Schwerpunkt-Teilmodulen soll die Prüfungsdauer 5 Minuten pro Leistungspunkt betragen. Erstreckt sich eine mündliche Prüfung über mehr als 12 LP soll die Prüfungsdauer 60 Minuten betragen.

Erfolgskontrollen anderer Art können beliebig oft wiederholt werden.

### 1.2 Module des Bachelorstudiums „B.Sc.“

Voraussetzung für die Zulassung zu den Fachprüfungen ist der Nachweis über die angegebenen Studienleistungen. Schriftliche Prüfungen werden als Klausuren mit der angegebenen Prüfungsdauer in Stunden abgenommen. Benotete Erfolgskontrollen gehen mit dem angegebenen Gewicht (Gew) in die Modulnote bzw. die Gesamtnote ein.

Das in § 18 Abs. 2 SPO beschriebene Modul „Schlüsselqualifikationen“ bilden die im nachfolgend aufgeführten Block (7) zusammengefassten Veranstaltungen „Arbeitstechniken im Maschinenbau“ und „MKL - Konstruieren im Team“ mit einem Umfang von 6 Leistungspunkten. Der in seinen fachspezifischen Inhalten dem untenstehenden Block (6) „Maschinenkonstruktionslehre“ zugeordnete und mit insgesamt 4 Leistungspunkten bewertete Workshop „MKL – Konstruieren im Team“ wird wegen den hier integrativ in teamorientierter Projektarbeit vermittelten Lehrinhalten mit 2 Leistungspunkten dem Block (7) „Schlüsselqualifikationen“ zugerechnet.

| Module                              | Veranstaltung                 | Koordinator | Studienleistung | LP | Erfolgskontrolle | Pr (h) | Gew |
|-------------------------------------|-------------------------------|-------------|-----------------|----|------------------|--------|-----|
| 1 Höhere Mathematik                 | Höhere Mathematik I           | Kirsch      | ÜSchein         | 7  | sPr              | 2      | 7   |
|                                     | Höhere Mathematik II          |             | ÜSchein         | 7  | sPr              | 2      | 7   |
|                                     | Höhere Mathematik III         |             | ÜSchein         | 7  | sPr              | 2      | 7   |
| 2 Naturwissenschaftliche Grundlagen | Grundlagen der Chemie         | Deutschmann |                 | 3  | sPr              | 2      | 3   |
|                                     | Wellenphänomene in der Physik | Pilawa      |                 | 4  | sPr              | 2      | 4   |
| 3 Technische Mechanik               | Technische Mechanik I         | Böhlke      | ÜSchein         | 6  | sPr              | 1,5    | 6   |
|                                     | Technische Mechanik II        | Böhlke      | ÜSchein         | 5  | sPr              | 1,5    | 5   |
|                                     | Technische Mechanik III       | Seemann     | ÜSchein         | 5  | sPr              | 3      | 10  |
|                                     | Technische Mechanik IV        | Seemann     | ÜSchein         | 5  |                  |        |     |

Studienplan der Fakultät für Maschinenbau für den Bachelor- und Masterstudiengang Maschinenbau. Gültig ab 01.10.2014, auf Beschlussfassung des Fakultätsrats am 16.07.2014 mit redaktionellen Änderungen vom 01.08.2014.

Seite 3 von 18

| Module                               | Veranstaltung                                    | Koordinator         | Studienleistung | LP | Erfolgskontrolle | Pr (h) | Gew |
|--------------------------------------|--|---------------------|-----------------|----|------------------|--------|-----|
| 4 Werkstoffkunde                     | Werkstoffkunde I                                 | Heilmaier           |                 | 7  | mPr              |        | 15  |
|                                      | Werkstoffkunde II                                |                     |                 | 5  |                  |        |     |
|                                      | Werkstoffkunde-Praktikum                         |                     | PSchein         | 3  |                  |        |     |
| 5 Technische Thermodynamik           | Technische Thermodynamik und Wärmeübertragung I  | Maas                | ÜSchein         | 7  | sPr              | 4      | 13  |
|                                      | Technische Thermodynamik und Wärmeübertragung II | Maas                | ÜSchein         | 6  |                  |        |     |
| 6 Maschinenkonstruktionslehre        | Maschinenkonstruktionslehre I                    | Albers              | ÜSchein         | 4  | sPr              | 5      | 18  |
|                                      | Maschinenkonstruktionslehre II                   |                     | ÜSchein         | 4  |                  |        |     |
|                                      | Maschinenkonstruktionslehre III                  |                     | ÜSchein         | 4  |                  |        |     |
|                                      | MKL – Konstruieren im Team (mkl III)             |                     | ÜSchein         | 1  |                  |        |     |
|                                      | Maschinenkonstruktionslehre IV                   |                     | ÜSchein         | 4  |                  |        |     |
|                                      | MKL –Konstruieren im Team (mkl IV)               |                     | ÜSchein         | 1  |                  |        |     |
| 7 Schlüsselqualifikationen           | Arbeitstechniken im Maschinenbau                 | Deml                |                 | 4  | Schein           | -      | 6   |
|                                      | MKL III – Konstruieren im Team                   | Albers              |                 | 1  | Schein           | -      |     |
|                                      | MKL IV – Konstruieren im Team                    |                     |                 | 1  | Schein           | -      |     |
| 8 Betriebliche Produktionswirtschaft | Betriebliche Produktionswirtschaft               | Furmans             |                 | 5  | sPr              | 1,5    | 5   |
| 9 Informatik                         | Informatik im Maschinenbau                       | Ovtcharova          | PSchein         | 8  | sPr              | 3      | 8   |
| 10 Elektrotechnik                    | Elektrotechnik und Elektronik                    | Becker              |                 | 8  | sPr              | 3      | 8   |
| 11 Mess- und Regelungstechnik        | Grundlagen der Mess- und Regelungstechnik        | Stiller             |                 | 7  | sPr              | 3      | 7   |
| 12 Strömungslehre                    | Strömungslehre                                   | Frohnapfel          |                 | 7  | sPr              | 3      | 7   |
| 13 Maschinen und Prozesse            | Maschinen und Prozesse                           | Kubach              | PSchein         | 7  | sPr              | 3      | 7   |
| 14 Wahlpflichtfach                   | siehe Kapitel 2.1                                |                     |                 | 5  | sPr/mPr          | 1,5-3  | 5   |
| 15 Schwerpunkt                       | Schwerpunkt-Kern siehe Kapitel 6                 | SP-Verantwortlicher |                 | 8  | mPr              |        | 8   |
|                                      | Schwerpunkt-Ergänzung siehe Kapitel 6            | SP-Verantwortlicher |                 | 4  | mPr              |        | 4   |

Erfolgskontrollen in Zusatzmodulen können schriftliche Prüfungen, mündliche Prüfungen oder Erfolgskontrollen anderer Art sein.

Zusätzlich ist ein Berufs-Fachpraktikum (s. Punkt 4) im Umfang von 6 Wochen zu absolvieren (8 LP).

Studienplan der Fakultät für Maschinenbau für den Bachelor- und Masterstudiengang Maschinenbau. Gültig ab 01.10.2014, auf Beschlussfassung des Fakultätsrats am 16.07.2014 mit redaktionellen Änderungen vom 01.08.2014.

**1.3 Studienplan des 1. Abschnitts des Bachelorstudiums „B.Sc.“**

| Lehrveranstaltungen<br>1. bis 4. Semester                  | WS<br>1. Sem. |    |    | SS<br>2. Sem. |     |    | WS<br>3. Sem. |   |   | SS<br>4. Sem. |   |   |
|--|---------------|----|----|---------------|-----|----|---------------|---|---|---------------|---|---|
|  | V             | Ü  | P  | V             | Ü   | P  | V             | Ü | P | V             | Ü | P |
| Höhere Mathematik I-III                                    | 4             | 2  |    | 4             | 2   |    | 4             | 2 |   |               |   |   |
| Grundlagen der Chemie                                      | 2             |    |    |               |     |    |               |   |   |               |   |   |
| Wellenphänomene in der Physik                              |               |    |    |               |     |    |               |   |   | 2             | 1 |   |
| Technische Mechanik I-IV                                   | 3             | 2  |    | 2             | 2   |    | 2             | 2 |   | 2             | 2 |   |
| Werkstoffkunde I, II                                       | 4             | 1  |    | 3             | 1   |    |               |   |   |               |   |   |
| Werkstoffkunde-Praktikum <sup>1</sup>                      |               |    |    |               |     | 2  |               |   |   |               |   |   |
| Technische Thermodynamik und Wärmeübertragung I, II        |               |    |    |               |     |    | 3             | 2 |   | 3             | 2 |   |
| Maschinenkonstruktionslehre I-IV                           | 2             | 1  |    | 2             | 2   |    | 2             | 2 |   | 2             | 1 |   |
| MKL – Konstruieren im Team                                 |               |    |    |               |     |    |               |   | 1 |               |   | 1 |
| Betriebliche Produktionswirtschaft                         |               |    |    | 3             | 1   |    |               |   |   |               |   |   |
| Informatik im Maschinenbau                                 | 2             | 2  | 2  |               |     |    |               |   |   |               |   |   |
| Elektrotechnik und Elektronik                              |               |    |    |               |     |    | 4             | 2 |   |               |   |   |
| Arbeitstechniken Maschinenbau                              |               |    |    |               |     |    |               |   |   | 1             |   | 1 |
| Berufliches Grundpraktikum<br>(6 Wochen vor Studienbeginn) |               |    |    |               |     |    |               |   |   |               |   |   |
| Lehrveranstaltungen<br>5. bis 6. Semester                  | WS<br>5. Sem. |    |    | SS<br>6. Sem. |     |    |               |   |   |               |   |   |
|  | V             | Ü  | P  | V             | Ü   | P  |               |   |   |               |   |   |
| Grundlagen der Mess- und Regelungstechnik                  | 3             | 1  |    |               |     |    |               |   |   |               |   |   |
| Strömungslehre   | 3             | 1  |    |               |     |    |               |   |   |               |   |   |
| Maschinen und Prozesse                                     | 2             |    | 2  |               |     |    |               |   |   |               |   |   |
| Wahlpflichtfach (2+1 bzw. 3 SWS)                           | 2             | 1  |    | (2)           | (1) |    |               |   |   |               |   |   |
| Schwerpunkt (6 SWS variabel)                               | 3             | () | () | 3             | ()  | () |               |   |   |               |   |   |
| Berufs-Fachpraktikum                                       | (6 Wochen)    |    |    |               |     |    |               |   |   |               |   |   |

**1.4 Studienplan des 2. Abschnitts des Bachelorstudiums „B.Sc.“**

Die Bachelorarbeit (12 LP) bildet den zweiten Abschnitt des Bachelorstudiums und ist im Anschluss an den ersten Abschnitt zu absolvieren. Die Durchführung und Benotung der Bachelorarbeit ist in § 11 der Studien- und Prüfungsordnung für den Bachelorstudiengang Maschinenbau geregelt.

<sup>1</sup> Das Werkstoffkunde-Praktikum findet in der vorlesungsfreien Zeit zwischen SS und WS statt und beansprucht eine Woche.

Studienplan der Fakultät für Maschinenbau für den Bachelor- und Masterstudiengang Maschinenbau. Gültig ab 01.10.2014, auf Beschlussfassung des Fakultätsrats am 16.07.2014 mit redaktionellen Änderungen vom 01.08.2014.

**1.5 Masterstudium mit Vertiefungsrichtungen**

Es stehen folgende Vertiefungsrichtungen zur Auswahl:

| Vertiefungsrichtung                                | Abk. | Verantwortlicher |
|--|------|------------------|
| Allgemeiner Maschinenbau                           | MSc  | Furmans          |
| Energie- und Umwelttechnik                         | E+U  | Maas             |
| Fahrzeugtechnik                                    | FzgT | Gauterin         |
| Mechatronik und Mikrosystemtechnik                 | M+M  | Bretthauer       |
| Produktentwicklung und Konstruktion                | PEK  | Albers           |
| Produktionstechnik                                 | PT   | Lanza            |
| Theoretischer Maschinenbau                         | ThM  | Böhlke           |
| Werkstoffe und Strukturen für Hochleistungssysteme | W+S  | Heilmaier        |

Das Masterstudium kann sowohl zum Winter- als auch zum Sommersemester aufgenommen werden. Wegen der freien Wahl der Module lässt sich für das Masterstudium kein allgemeingültiger Studienplan angeben. Die Wahlmöglichkeiten in den Wahlpflichtfächern und Schwerpunkten richten sich nach der gewählten Vertiefungsrichtung. Schriftliche Prüfungen werden als Klausuren mit der angegebenen Prüfungsdauer in Stunden abgenommen. Benotete Erfolgskontrollen gehen mit dem angegebenen Gewicht (Gew) in die Gesamtnote ein.

Folgende Module sind im Masterstudiengang zu belegen:

| Module |                                    | Veranstaltung  | LP | Erfolgskontrolle | Pr. (h) | Gew |
|--------|------------------------------------|--|----|------------------|---------|-----|
| 1.     | Wahlpflichtfach 1                  | siehe Kapitel 2.1                                    | 5  | sPr/mPr          | 1,5-3/  | 5   |
| 2.     | Wahlpflichtfach 2                  | siehe Kapitel 2.1                                    | 5  | sPr/mPr          | 1,5-3/  | 5   |
| 3.     | Wahlpflichtfach 3                  | siehe Kapitel 2.1                                    | 5  | sPr/mPr          | 1,5-3/  | 5   |
| 4.     | Wahlfach                           | siehe Kapitel 2.5                                    | 4  | mPr              |         | 4   |
| 5.     | Modellbildung und Simulation       | Modellbildung und Simulation                         | 7  | sPr              | 3       | 7   |
| 6.     | Produktentstehung                  | Produktentstehung – Entwicklungsmethodik             | 6  | sPr              | 2       | 15  |
|        |                                    | Produktentstehung – Fertigungs- und Werkstofftechnik | 9  | sPr              | 3       |     |
| 7.     | Fachpraktikum                      | Siehe Kapitel 3                                      | 3  | Schein           |         |     |
| 8.     | Mathematische Methoden             | siehe Kapitel 2.2                                    | 6  | sPr              | 3       | 6   |
| 9.     | Schwerpunkt 1 – Kern und Ergänzung | siehe Kapitel 6                                      | 16 | mPr              |         | 16  |
| 10.    | Schwerpunkt 2 – Kern und Ergänzung | siehe Kapitel 6                                      | 16 | mPr              |         | 16  |
| 11.    | Wahlfach Nat/inf/etit              | siehe Kapitel 2.3                                    | 6  | Schein           |         |     |
| 12.    | Wahlfach Wirtschaft/Recht          | siehe Kapitel 2.4                                    | 4  | Schein           |         |     |

Erfolgskontrollen in Zusatzmodulen können schriftliche Prüfungen, mündliche Prüfungen oder Erfolgskontrollen anderer Art sein.

Zusätzlich ist ein Berufspraktikum im Umfang von 6 Wochen zu absolvieren (8 LP). Im Anschluss an die Modulprüfungen ist eine Masterarbeit (20 LP) zu erstellen.

Studienplan der Fakultät für Maschinenbau für den Bachelor- und Masterstudiengang Maschinenbau. Gültig ab 01.10.2014, auf Beschlussfassung des Fakultätsrats am 16.07.2014 mit redaktionellen Änderungen vom 01.08.2014.

## 2 Zugelassene Wahl- und Wahlpflichtfächer

Jedes Fach bzw. jedes Modul kann nur einmal im Rahmen des Bachelorstudienganges und des konsekutiven Masterstudiengangs Maschinenbau gewählt werden.

### 2.1 Wahlpflichtfächer im Bachelor- und Masterstudiengang

Im Bachelorstudiengang muss ein Wahlpflichtfach (WPF) gewählt werden. Im Masterstudiengang werden drei WPF abhängig von der jeweiligen Vertiefungsrichtung belegt.

In den Vertiefungsrichtungen ist die Wahl der WPF eingeschränkt: Eines der mit „p“ gekennzeichneten WPF muss gewählt werden, die beiden anderen WPF müssen aus dem mit w gekennzeichneten Angebot ausgewählt werden. In einem konsekutiven Masterstudium kann ein solches p-Wahlpflichtfach durch ein w-Wahlpflichtfach ersetzt werden, wenn das entsprechende Wahlpflichtfach bereits im Bachelorstudium belegt wurde. Für manche Schwerpunkte kann die Wahl eines Wahlpflichtfachs empfohlen sein (siehe Hinweis beim jeweiligen Schwerpunkt im aktuellen Modulhandbuch).

Folgende Wahlpflichtfächer (WPF) sind derzeit vom Fakultätsrat für den Bachelorstudiengang und die Vertiefungsrichtungen des Masterstudiengangs genehmigt.

| Nr.  | Wahlpflichtfächer (WPF)  | B.Sc. | MSc | E+U | FzgT | M+M | PEK | PT | ThM | W+S |
|------|--|-------|-----|-----|------|-----|-----|----|-----|-----|
| (1)  | Arbeitswissenschaft  |       | w   |     |      |     | w   | w  |     |     |
| (2)  | Einführung in die Mechatronik                                      | w     | w   | w   | w    | p   | w   | w  |     |     |
| (3)  | Elektrotechnik II  |       |     |     | w    |     |     |    |     |     |
| (4)  | Fluidtechnik   | w     | w   | w   | w    |     | w   | w  | w   |     |
| (5)  | Wahrscheinlichkeitstheorie und Statistik                           |       |     |     | w    | w   |     |    | w   |     |
| (6)  | Einführung in die Mehrkörperrdynamik                               | w     | w   | w   | w    | w   | w   | w  | w   | w   |
| (7)  | Mathematische Methoden der Dynamik                                 | w     | w   |     | w    | w   | w   |    | w   |     |
| (8)  | Mathematische Methoden der Festigkeitslehre                        | w     | w   |     | w    | w   | w   | w  | w   | w   |
| (9)  | Mathematische Methoden der Schwingungslehre                        | w     | w   |     | w    | w   | w   |    | w   |     |
| (10) | Mathematische Methoden der Strömungslehre                          | w     | w   | w   | w    |     |     |    | w   |     |
| (11) | Mathematische Methoden der Strukturmechanik                        |       | w   |     |      | w   | w   |    | w   | w   |
| (12) | Grundlagen der Mikrosystemtechnik I <u>oder</u> II                 |       | w   |     |      | w   | w   | w  |     |     |
| (13) | Physikalische Grundlagen der Lasertechnik                          | w     | w   | w   | w    | w   | w   | w  |     | w   |
| (14) | Numerische Mathematik für Informatiker und Ingenieure              |       |     | w   | w    | w   |     | w  | w   |     |
| (15) | Einführung in die moderne Physik <u>oder</u> Physik für Ingenieure | w     | w   | w   | w    | w   |     |    | w   | w   |
| (16) | Product Lifecycle Management                                       | w     | w   |     | w    | w   | w   | w  |     |     |

Studienplan der Fakultät für Maschinenbau für den Bachelor- und Masterstudiengang Maschinenbau. Gültig ab 01.10.2014, auf Beschlussfassung des Fakultätsrats am 16.07.2014 mit redaktionellen Änderungen vom 01.08.2014.

Seite 7 von 18

| Nr.  | Wahlpflichtfächer (WPF)                                 | B.Sc. | MSc | E+U | FzgT | M+M | PEK | PT | ThM | W+S |
|------|---|-------|-----|-----|------|-----|-----|----|-----|-----|
| (17) | Simulation von Produktionssystemen und -prozessen       | w     | w   |     |      |     |     | w  |     |     |
| (18) | Mathematische Modelle von Produktionssystemen           |       | w   |     |      |     |     | w  | w   |     |
| (19) | Systematische Werkstoffauswahl                          | w     | w   | w   | w    | w   | w   | w  | w   | p   |
| (20) | Wärme- und Stoffübertragung                             | w     | w   | p   | w    | w   | w   |    | w   |     |
| (21) | Technische Informationssysteme                          | w     | w   |     | w    | w   | w   | w  |     |     |
| (22) | Modellierung und Simulation                             | w     | w   |     |      |     |     | w  | w   | w   |
| (23) | Wissenschaftliches Programmieren für Ingenieure mit Üb. | w     | w   |     |      |     |     |    | w   | w   |
| (24) | Mikrostruktursimulation                                 | w     | w   |     |      |     |     |    | w   | w   |
| (25) | CAE-Workshop  | w     | w   | w   | w    | w   | w   | w  |     | w   |
| (26) | Grundlagen der technischen Verbrennung I                | w     | w   | w   | w    | w   |     |    | w   |     |
| (27) | Grundlagen der technischen Logistik                     | w     | w   | w   | w    | w   | w   | w  | w   | w   |
| (28) | Virtual Engineering Specific Topics                     | w     |     |     |      |     |     |    |     |     |
| (29) | Gelöscht  |       |     |     |      |     |     |    |     |     |
| (30) | Industrial Management Case Study                        | w     |     |     |      |     |     |    |     |     |
| (31) | Maschinendynamik  | w     | w   | w   | w    | w   | w   | w  | w   | w   |
| (32) | Technische Schwingungslehre                             | w     | w   | w   | w    | w   | w   | w  | w   | w   |
| (33) | Mathématiques appliquées aux Sciences de l'Ingénieur    | w     |     |     |      |     |     |    |     |     |
| (34) | Grundlagen des Verbrennungsmotors I                     | w     | w   | w   | w    | w   | w   |    |     |     |
| (35) | Neue Aktoren und Sensoren                               |       | w   | w   | w    | w   | w   | w  |     |     |

Im Masterstudiengang kann ein Wahlpflichtfach aus der Liste der wählbaren Veranstaltungen für das Wahlfach (2.5) gewählt werden.

## 2.2 Mathematische Methoden im Masterstudiengang

Wählbare Veranstaltungen siehe Modulhandbuch.

## 2.3 Wahlfach aus dem Bereich Naturwissenschaften/Informatik/Elektrotechnik im Masterstudiengang

Wählbare Veranstaltungen siehe Modulhandbuch. Der Wechsel der gewählten Veranstaltung ist bis zum Bestehen der Erfolgskontrolle möglich. Andere Veranstaltungen, auch aus anderen Fakultäten, können mit Genehmigung der Prüfungskommission gewählt werden.

## 2.4 Wahlfach aus dem Bereich Wirtschaft/Recht im Masterstudiengang

Wählbare Veranstaltungen siehe Modulhandbuch. Der Wechsel der gewählten Veranstaltung ist bis zum Bestehen der Erfolgskontrolle möglich. Andere Veranstaltungen, auch aus anderen Fakultäten, können mit Genehmigung der Prüfungskommission gewählt werden.

## 2.5 Wahlfach im Masterstudiengang

Wählbare Veranstaltungen siehe Modulhandbuch. Andere Veranstaltungen, auch aus anderen Fakultäten, können mit Genehmigung der Prüfungskommission gewählt werden.

## 3 Fachpraktikum im Masterstudiengang

Wählbare Veranstaltungen siehe Modulhandbuch. Der Wechsel der gewählten Veranstaltung ist bis zum Bestehen der Erfolgskontrolle möglich.

## 4 Berufspraktikum

Das Berufspraktikum (gemäß SPO § 12) besteht im Bachelorstudiengang aus Grund- und Fachpraktikum (je 6 Wochen) und im Masterstudiengang aus einem Fachpraktikum (6 Wochen). Das Grundpraktikum sollte möglichst in einem geschlossenen Zeitraum vor Beginn des Bachelorstudiums durchgeführt werden. Die Abschnitte der Fachpraktika (im Weiteren Berufs-Fachpraktikum genannt) im Rahmen des Bachelor- und des Masterstudiums sollen in geschlossenen Zeiträumen in beliebiger Reihenfolge durchgeführt werden.

### 4.1 Inhalt und Durchführung des Berufspraktikums

Nicht das Praktikantenamt, sondern das für den Wohnsitz des Interessenten zuständige Arbeitsamt und mancherorts auch die Industrie- und Handelskammer weisen geeignete und anerkannte Ausbildungsbetriebe nach. Da Praktikantenstellen nicht vermittelt werden, müssen sich die Interessenten selbst mit der Bitte um einen Praktikantenplatz an die Betriebe wenden. Das Praktikantenverhältnis wird rechtsverbindlich durch den zwischen dem Betrieb und dem Praktikanten abzuschließenden Ausbildungsvertrag. Im Vertrag sind alle Rechte und Pflichten des Praktikanten und des Ausbildungsbetriebes sowie Art und Dauer der berufspraktischen Tätigkeit festgelegt. Betrieb steht hier synonym für Firmen, Unternehmen etc., die eine anerkannte Ausbildungsstätte beinhalten.

Um eine ausreichende Breite der berufspraktischen Ausbildung zu gewährleisten, sollen sowohl für das Grundpraktikum als auch für die Berufs-Fachpraktika Tätigkeiten aus verschiedenen Arbeitsgebieten nachgewiesen werden.

Die Tätigkeiten im Grundpraktikum können aus folgenden Gebieten gewählt werden:

- spanende Fertigungsverfahren,
- umformende Fertigungsverfahren,
- urformende Fertigungsverfahren und
- thermische Füge- und Trennverfahren.

Es sollen Tätigkeiten in mindestens drei der o.g. Gebiete nachgewiesen werden.

Die Tätigkeiten im Berufs-Fachpraktikum müssen inhaltlich denen eines Ingenieurs entsprechen und können aus folgenden Gebieten gewählt werden:

- Wärmebehandlung,
- Werkzeug- und Vorrichtungsbau,
- Instandhaltung, Wartung und Reparatur,
- Qualitätsmanagement,
- Oberflächentechnik,
- Entwicklung, Konstruktion und Arbeitsvorbereitung,
- Montage/Demontage und
- andere fachrichtungsbezogene praktische Tätigkeiten entsprechend den gewählten Schwerpunkten (evtl. in Absprache mit dem Praktikantenamt).

Aus diesen acht Gebieten sollen im Bachelor mindestens drei, im Master mindestens zwei weitere unterschiedliche Gebiete nachgewiesen werden. Dabei wird empfohlen, dass die Tätigkeiten aus dem Gebiet des im Studium gewählten Schwerpunktes bzw. der im Master gewählten Vertiefungsrichtung sind oder damit in Zusammenhang stehen.

Tätigkeiten, die an Universitäten, gleichgestellten Hochschulen oder in vergleichbaren Forschungseinrichtungen durchgeführt wurden, werden grundsätzlich nicht als Berufs-Fachpraktikum anerkannt.

Die vorgeschriebenen 12 bzw. 6 Wochen des Berufspraktikums sind als Minimum zu betrachten. Es wird empfohlen, freiwillig weitere praktische Tätigkeiten in einschlägigen Betrieben durchzuführen.

Fragen der Versicherungspflicht regeln entsprechende Gesetze. Während des Praktikums im Inland sind die Studierenden weiterhin Angehörige der Universität und entsprechend versichert. Versicherungsschutz für Auslandspraktika gewährleistet eine Auslandsversicherung, die vom Praktikanten oder dem Ausbildungsbetrieb abgeschlossen wird.

Ausgefallene Arbeitszeit muss in jedem Falle nachgeholt werden. Bei Ausfallzeiten sollte der Praktikant den auszubildenden Betrieb um eine Vertragsverlängerung ersuchen, um den begonnenen Abschnitt seiner berufspraktischen Tätigkeit im erforderlichen Maße durchführen zu können.

## 4.2 Anerkennung des Berufspraktikums

Die Anerkennung des Berufspraktikums erfolgt durch das Praktikantenamt der Fakultät für Maschinenbau. Zur Anerkennung ist die Vorlage des Ausbildungsvertrags, eines ordnungsgemäß abgefassten Praktikumsberichts für das Grundpraktikum (von der Firma bestätigt) und eines Original-Tätigkeitsnachweises (Zeugnis) für das Berufs-Fachpraktikum erforderlich. Art und Dauer der einzelnen Tätigkeitsabschnitte müssen aus den Unterlagen klar ersichtlich sein.

Für das Grundpraktikum muss ein Bericht angefertigt werden, der eine geistige Auseinandersetzung mit dem bearbeiteten Thema erkennen lässt. Eine chronologische Auflistung der Tätigkeiten oder eine reine Prozessbeschreibung ist hierfür nicht ausreichend. Die Praktikanten berichten über ihre Tätigkeiten und die dabei gemachten Beobachtungen und holen dazu die Bestätigung des Ausbildungsbetriebes ein. Die Berichterstattung umfasst wöchentliche Arbeitsberichte (Umfang ca. 1 DIN A4-Seite pro Woche) für das Grundpraktikum. Dabei ist die Form frei wählbar (Handschrift, Textsystem, Computergraphik, etc.).

Zur Anerkennung des Berufs-Fachpraktikums wird ein Zertifikat des Ausbildungsbetriebes („Praktikantenzugnis“) benötigt, das Art und Dauer der Tätigkeiten während des Berufs-Fachpraktikums beschreibt. Eventuelle Fehltage sind zu vermerken und müssen nachgeholt werden. Zu Fehltagen zählen u.a. auch Urlaubstage und Abwesenheit wegen Arbeitsunfähigkeit.

Das Praktikantenamt entscheidet, inwieweit die praktische Tätigkeit der Praktikantenordnung entspricht und daher als Praktikum anerkannt werden kann. Ein Praktikum, über das nur unzureichende (unvollständige oder nicht verständlich abgefasste) Berichte vorliegen, wird nur zu einem Teil der Dauer anerkannt.

Wird im Rahmen des Bachelorstudiums ein Berufs-Fachpraktikum anerkannt, das die geforderte Mindestdauer von 6 Wochen überschreitet, so wird die Verlängerungsdauer im Rahmen des konsekutiven Masterstudiums als Berufs-Fachpraktikumszeit anerkannt.

Es wird nachdrücklich empfohlen, einen Teil des Berufspraktikums im Ausland abzuleisten. Für das Berufsleben ist es vorteilhaft, Teile insbesondere des Berufs-Fachpraktikums im Ausland durchzuführen. Berufspraktische Tätigkeiten in ausländischen Betrieben werden nur anerkannt, wenn sie den o.a. Richtlinien entsprechen und Berichte in der im Studienplan genannten Form angefertigt werden.

Für Ausländer aus Ländern, die nicht zur europäischen Union gehören, gelten diese Richtlinien ebenfalls.

## 4.3 Sonderbestimmungen zur Anerkennung

Eine Lehre, die den Anforderungen des Berufspraktikums entspricht, wird anerkannt. Bei der Bundeswehr erbrachte Ausbildungszeiten in Instandsetzungseinheiten sind mit maximal 6 Wochen als Berufspraktikum anrechenbar, wenn Tätigkeiten gemäß Kapitel 4.1 durchgeführt wurden. Zwecks Anerkennung sind die entsprechenden Berichte und Bescheinigungen (Ausbildungs- und Tätigkeitsnummer und Materialerhaltungsstufe) beim Praktikantenamt einzureichen.

Die praktische Ausbildung an Technischen Gymnasien wird entsprechend den nachgewiesenen Schulstunden als Grundpraktikum anerkannt. Hierbei können maximal 6 Wochen (entspricht 240 Vollzeit-Stunden) auf die berufspraktische Tätigkeit angerechnet werden.

Während des Bachelorstudiums erbrachte Berufspraktika können im Masterstudium anerkannt werden, sofern sie nicht bereits als Berufspraktikum für den Bachelorstudiengang anerkannt wurden.

## 5 Bachelor- und Masterarbeit

Die Bachelorarbeit darf an allen Instituten der Fakultät Maschinenbau absolviert werden.  
Für die Betreuung der Masterarbeit stehen je nach Vertiefungsrichtung folgende Institute (●) zur Wahl:

| Institut für   | Abk.    | MSc | E+UT | FzgT | M+M | PEK | PT | ThM | W+S |
|--|---------|-----|------|------|-----|-----|----|-----|-----|
| Angewandte Informatik/ Automatisierungstechnik       | AIA     | ●   | ●    | ●    | ●   | ●   | ●  | ●   | ●   |
| Angewandte Werkstoffphysik                           | IAM-AWP | ●   | ●    | ●    | ●   | ●   | –  | ●   | ●   |
| Arbeitswissenschaft und Betriebsorganisation         | ifab    | ●   | ●    | –    | –   | ●   | ●  | –   | –   |
| Fahrzeugsystemtechnik                                | FAST    | ●   | ●    | ●    | ●   | ●   | –  | ●   | ●   |
| Fördertechnik und Logistiksysteme                    | IFL     | ●   | –    | –    | –   | ●   | ●  | ●   | –   |
| Informationsmanagement im Ingenieurwesen             | IMI     | ●   | –    | ●    | ●   | ●   | ●  | –   | –   |
| Keramik im Maschinenbau                              | IAM-KM  | ●   | ●    | –    | –   | ●   | –  | –   | ●   |
| Fusionstechnologie und Reaktortechnik                | IFRT    | ●   | ●    | –    | –   | –   | –  | –   | –   |
| Kolbenmaschinen                                      | IFKM    | ●   | ●    | ●    | –   | ●   | –  | –   | –   |
| Mess- und Regelungstechnik mit Maschinenlaboratorium | MRT     | ●   | ●    | ●    | ●   | ●   | –  | ●   | –   |
| Mikrostrukturtechnik                                 | IMT     | ●   | ●    | ●    | ●   | ●   | ●  | –   | –   |
| Produktentwicklung                                   | IPEK    | ●   | ●    | ●    | ●   | ●   | ●  | –   | ●   |
| Produktionstechnik                                   | WBK     | ●   | –    | ●    | ●   | ●   | ●  | –   | ●   |
| Strömungsmechanik                                    | ISTM    | ●   | ●    | ●    | –   | –   | –  | ●   | –   |
| Fachgebiet Strömungsmaschinen                        | FSM     | ●   | ●    | ●    | –   | ●   | –  | –   | –   |
| Technische Mechanik                                  | ITM     | ●   | ●    | ●    | ●   | ●   | ●  | ●   | ●   |
| Thermische Strömungsmaschinen                        | ITS     | ●   | ●    | ●    | –   | ●   | –  | ●   | ●   |
| Technische Thermodynamik                             | ITT     | ●   | ●    | ●    | –   | –   | –  | ●   | –   |
| Werkstoff- und Biomechanik                           | IAM-WBM | ●   | ●    | ●    | ●   | ●   | ●  | ●   | ●   |
| Werkstoffkunde                                       | IAM-WK  | ●   | ●    | ●    | ●   | ●   | ●  | ●   | ●   |
| Zuverlässigkeit von Bauteilen und Systemen           | IAM-ZBS | ●   | ●    | ●    | ●   | ●   | –  | ●   | ●   |

In interdisziplinär ausgerichteten Vertiefungsrichtungen ist die Beteiligung von Instituten anderer Fakultäten erwünscht. Mit Zustimmung der Vertiefungsrichtungsverantwortlichen kann die Prüfungskommission auch Masterarbeiten an anderen Instituten der Fakultät für Maschinenbau genehmigen. Zustimmung und Genehmigung sind vor Beginn der Arbeit einzuholen.

## 6 Schwerpunkte im Bachelor- und im Masterstudiengang

Generell gilt, dass jede Lehrveranstaltung und jeder Schwerpunkt nur einmal entweder im Rahmen des Bachelor- oder des Masterstudiengangs gewählt werden kann.

### 6.1 Zuordnung der Schwerpunkte zum Bachelorstudiengang und zu den Vertiefungsrichtungen des Masterstudiengangs

Folgende Schwerpunkte sind derzeit vom Fakultätsrat für den Bachelor- und den Masterstudiengang genehmigt. In einigen Vertiefungsrichtungen ist die Wahl des **ersten** Masterschwerpunkts eingeschränkt (einer der mit „p“ gekennzeichneten Schwerpunkte ist zu wählen).

In einem konsekutiven Masterstudium kann der erste Masterschwerpunkt auch als w-Schwerpunkt gewählt werden, wenn ein p-Schwerpunkt dieser Vertiefungsrichtung bereits im Bachelorstudium gewählt wurde.

| Nr.  | Schwerpunkt  | B.Sc. | MSc | E+U | FzgT | M+M | PEK | PT | ThM | W+S |
|------|--|-------|-----|-----|------|-----|-----|----|-----|-----|
| (1)  | Advanced Mechatronics  |       | w   | w   | w    | p   | w   | w  | w   |     |
| (2)  | Antriebssysteme  | w     | w   |     | w    |     | w   | w  |     |     |
| (3)  | Arbeitswissenschaft  |       | w   | w   |      |     | w   | p  |     |     |
| (4)  | Automatisierungstechnik  |       | w   | w   | w    | p   | w   | w  | w   |     |
| (5)  | Berechnungsmethoden im MB  | w     | w   | w   | w    |     |     |    | w   |     |
| (6)  | Computational Mechanics  |       | w   |     | w    | w   | w   |    | p   |     |
| (7)  | Gelöscht   |       |     |     |      |     |     |    |     |     |
| (8)  | Dynamik und Schwingungslehre                                     |       | w   | w   | w    |     | w   |    | p   |     |
| (9)  | Dynamische Maschinenmodelle                                      | w     | w   |     |      |     |     | w  | w   |     |
| (10) | Entwicklung und Konstruktion                                     | w     | w   | w   | w    |     | w   | w  |     |     |
| (11) | Fahrdynamik, Fahrzeugkomfort und -akustik                        |       | w   |     | w    | w   | w   |    | w   |     |
| (12) | Kraftfahrzeugtechnik   | w     | w   |     | p    |     | w   |    |     |     |
| (13) | Festigkeitslehre/ Kontinuumsmechanik                             | w     |     |     |      |     |     |    |     |     |
| (14) | Gelöscht   |       |     |     |      |     |     |    |     |     |
| (15) | Grundlagen der Energietechnik                                    | w     | w   | p   | w    | w   | w   |    |     |     |
| (16) | Industrial Engineering (engl.)                                   |       | w   |     |      |     | w   | w  |     |     |
| (17) | Informationsmanagement   | w     |     |     |      |     |     |    |     |     |
| (18) | Informationstechnik  | w     | w   | w   | w    | w   | w   | w  | w   |     |
| (19) | Informationstechnik für Logistiksysteme                          |       | w   |     |      |     | w   | w  |     |     |
| (20) | Integrierte Produktentwicklung                                   |       | w   | w   | w    |     | p   | w  |     |     |
| (21) | Kerntechnik  |       | w   | w   |      |     |     |    | w   |     |
| (22) | Kognitive Technische Systeme                                     |       | w   |     | w    | w   | w   | w  | w   |     |
| (23) | Kraftwerkstechnik  |       | w   | w   |      |     | w   |    |     |     |
| (24) | Kraft- und Arbeitsmaschinen                                      | w     | w   | w   | w    |     | w   |    |     |     |
| (25) | Leichtbau  |       | w   | w   | w    |     | w   | w  |     | w   |
| (26) | Materialwissenschaft und Werkstofftechnik                        | w     | w   | w   | w    | w   | w   | w  | w   | p   |
| (27) | Modellierung und Simulation in der Energie- und Strömungstechnik |       | w   | w   | w    | w   | w   |    |     |     |

Studienplan der Fakultät für Maschinenbau für den Bachelor- und Masterstudiengang Maschinenbau. Gültig ab 01.10.2014, auf Beschlussfassung des Fakultätsrats am 16.07.2014 mit redaktionellen Änderungen vom 01.08.2014.

Seite 13 von 18

| Nr.  | Schwerpunkt                             | B.Sc. | MSc | E+U | FzgT | M+M | PEK | PT | ThM | W+S |
|------|---|-------|-----|-----|------|-----|-----|----|-----|-----|
| (28) | Lifecycle Engineering                   |       | w   |     | w    | w   | p   | p  |     |     |
| (29) | Logistik und Materialflusslehre         |       | w   |     |      |     | w   | p  |     |     |
| (30) | Angewandte Mechanik                     |       | w   | w   | w    | w   | w   | w  | p   | w   |
| (31) | Mechatronik                             | w     | w   | w   | w    | p   | w   | w  | w   |     |
| (32) | Medizintechnik                          |       | w   |     |      | w   | w   |    |     |     |
| (33) | Mikrosystemtechnik                      |       | w   | w   | w    | p   | w   | w  |     |     |
| (34) | Mobile Arbeitsmaschinen                 |       | w   |     | p    | w   | w   | w  |     |     |
| (35) | Modellbildung und Simulation            |       | w   |     | w    | w   | w   | w  | p   | w   |
| (36) | Polymerengineering                      |       | w   | w   | w    |     | w   | w  |     | w   |
| (37) | Produktionsmanagement                   |       | w   |     |      |     |     | w  |     |     |
| (38) | Produktionssysteme                      | w     |     |     |      |     |     |    |     |     |
| (39) | Produktionstechnik                      |       | w   |     | w    |     | w   | p  |     |     |
| (40) | Robotik                                 |       | w   |     |      | p   | w   | w  | w   |     |
| (41) | Strömungslehre                          |       | w   | w   | w    |     | w   |    | p   |     |
| (42) | Gelöscht                                |       |     |     |      |     |     |    |     |     |
| (43) | Technische Keramik und Pulverwerkstoffe |       | w   | w   | w    |     | w   |    |     | w   |
| (44) | Technische Logistik                     | w     | w   |     |      |     | w   | w  |     |     |
| (45) | Technische Thermodynamik                |       | w   | w   | w    | w   | w   |    | w   | w   |
| (46) | Thermische Turbomaschinen               |       | w   | w   | w    |     |     |    | w   | w   |
| (47) | Tribologie                              |       | w   | w   | w    | w   | w   | w  | w   | w   |
| (48) | Gelöscht                                |       |     |     |      |     |     |    |     |     |
| (49) | Zuverlässigkeit im Maschinenbau         |       | w   | w   | w    | w   | w   | w  | w   | p   |
| (50) | Bahnsystemtechnik                       | w     | w   |     | p    | w   | w   |    |     |     |
| (51) | Entwicklung innovativer Geräte          |       | w   | w   | w    |     | p   | w  |     |     |
| (52) | Production Engineering                  | w     |     |     |      |     |     |    |     |     |
| (53) | Fusionstechnologie                      |       | w   | w   |      |     |     |    | w   |     |
| (54) | Mikroaktoren und Mikrosensoren          |       | w   | w   | w    | w   | w   | w  |     |     |
| (55) | Gebäudeenergie-technik                  |       | w   |     |      |     |     |    |     |     |
| (56) | Advanced Materials Modelling            |       | w   |     |      |     |     |    | w   | w   |
| (57) | Grundlagen des Verbrennungsmotors       | w     |     |     |      |     |     |    |     |     |
| (58) | Verbrennungsmotorische Antriebssysteme  |       | w   | w   | p    | w   | w   |    |     |     |

Im Masterstudiengang Maschinenbau ohne Vertiefungsrichtung dürfen nur zwei Schwerpunkte kombiniert werden, die von zwei verschiedenen Instituten dominiert werden.

### 6.2 Wahlmöglichkeiten für den Schwerpunkt im Bachelorstudiengang

Für den Schwerpunkt werden mindestens 12 LP gewählt, davon müssen mindestens 8 LP Kernmodulfächer (K) sein, die im Block geprüft werden. „KP“ bedeutet, dass das Fach im Kernmodulbereich Pflicht ist, sofern es nicht bereits belegt wurde. Die übrigen Leistungspunkte können auch aus dem Ergänzungsbereich (E) kommen. Dabei dürfen nicht mehr als 4 LP Praktika belegt werden, die auch mit einer unbenoteten Erfolgskontrolle abgeschlossen werden können. Die Bildung der Schwerpunktnote erfolgt dann anhand der mit einer Benotung abgeschlossenen Teilmodule.

Studienplan der Fakultät für Maschinenbau für den Bachelor- und Masterstudiengang Maschinenbau. Gültig ab 01.10.2014, auf Beschlussfassung des Fakultätsrats am 16.07.2014 mit redaktionellen Änderungen vom 01.08.2014.

Die als Ergänzungsfächer (E) angegebenen Veranstaltungen verstehen sich als Empfehlung, andere Fächer auch aus anderen Fakultäten, können mit Genehmigung des jeweiligen Schwerpunkt-Verantwortlichen gewählt werden. Dabei ist eine Kombination mit Veranstaltungen aus den Bereichen Informatik, Elektrotechnik und Mathematik in einigen Vertiefungsrichtungen besonders willkommen. Mit „EM“ gekennzeichnete Fächer stehen nur im Masterstudiengang zur Wahl. Für manche Schwerpunkte ist die Belegung von bestimmten Wahlpflichtfächern (WPF) empfohlen.

Es dürfen im Schwerpunkt maximal 16 LP erworben werden. In jedem Fall werden bei der Festlegung der Schwerpunktnote alle Teilmodulnoten gemäß ihrer Leistungspunkte gewichtet. Bei der Bildung der Gesamtnote wird der Schwerpunkt mit 12 LP gewertet.

### 6.3 Wahlmöglichkeiten in den einzelnen Schwerpunkten im Masterstudiengang

Für jeden Schwerpunkt werden mindestens 16 LP gewählt, davon müssen mindestens 8 LP Kernmodulfächer (K) sein, die im Block geprüft werden. „KP“ bedeutet, dass das Fach im Kernmodulbereich Pflicht ist, sofern es nicht bereits belegt wurde. Die übrigen Leistungspunkte können auch aus dem Ergänzungsbereich (E) kommen. Dabei dürfen nicht mehr als 4 LP Praktika belegt werden, die auch mit einer unbenoteten Erfolgskontrolle abgeschlossen werden können. Die Bildung der Schwerpunktnote erfolgt dann anhand der mit einer Benotung abgeschlossenen Teilmodule.

Die als Ergänzungsfächer (E) angegebenen Veranstaltungen verstehen sich als Empfehlung, andere Fächer auch aus anderen Fakultäten, können mit Genehmigung des jeweiligen Schwerpunkt-Verantwortlichen gewählt werden. Dabei ist eine Kombination mit Veranstaltungen aus den Bereichen Informatik, Elektrotechnik und Mathematik in einigen Vertiefungsrichtungen besonders willkommen. Mit „EM“ gekennzeichnete Fächer stehen nur im Masterstudiengang zur Wahl. Für manche Schwerpunkte ist die Belegung von bestimmten Wahlpflichtfächern (WPF) empfohlen.

Bei der Festlegung der Schwerpunktnote werden alle Teilmodulnoten gemäß ihrer Leistungspunkte gewichtet. Bei der Bildung der Gesamtnote wird jeder Schwerpunkt mit 16 LP gewertet.

### 6.4 Schwerpunkte im Bachelor- und im Masterstudiengang Maschinenbau

Die Beschreibung der Schwerpunkte hinsichtlich der jeweils darin enthaltenen Lehrveranstaltungen sind in den aktuellen Modulhandbüchern des Bachelor- und Masterstudiengangs nachzulesen.

- SP 1: Advanced Mechatronics (Bretthauer)
- SP 2: Antriebssysteme (Albers)
- SP 3: Arbeitswissenschaft (Deml)
- SP 4: Automatisierungstechnik (Bretthauer)
- SP 5: Berechnungsmethoden im MB (Seemann)
- SP 6: Computational Mechanics (Proppe)
- SP 8: Dynamik und Schwingungslehre (Seemann)
- SP 9: Dynamische Maschinenmodelle (Seemann)
- SP 10: Entwicklung und Konstruktion (Albers)
- SP 11: Fahrdynamik, Fahrzeugkomfort und -akustik (Gauterin)
- SP 12: Kraftfahrzeugtechnik (Gauterin)
- SP 13: Festigkeitslehre/ Kontinuumsmechanik (Böhlke)
- SP 15: Grundlagen der Energietechnik (Bauer)
- SP 16: Industrial Engineering (engl.) (Deml)
- SP 17: Informationsmanagement (Ovtcharova)
- SP 18: Informationstechnik (Stiller)
- SP 19: Informationstechnik für Logistiksysteme (Furmans)
- SP 20: Integrierte Produktentwicklung (Albers)
- SP 21: Kerntechnik (Cheng)
- SP 22: Kognitive Technische Systeme (Stiller)
- SP 23: Kraftwerkstechnik (Bauer)

- SP 24: Kraft- und Arbeitsmaschinen (Gabi)
- SP 25: Leichtbau (F. Henning)
- SP 26: Materialwissenschaft und Werkstofftechnik (Heilmaier)
- SP 27: Modellierung und Simulation in der Energie- und Strömungstechnik (Maas)
- SP 28: Lifecycle Engineering (Ovtcharova)
- SP 29: Logistik und Materialflusslehre (Furmans)
- SP 30: Angewandte Mechanik (Böhlke)
- SP 31: Mechatronik (Bretthauer)
- SP 32: Medizintechnik (Bretthauer)
- SP 33: Mikrosystemtechnik (Saile, Last)
- SP 34: Mobile Arbeitsmaschinen (Geimer)
- SP 35: Modellbildung und Simulation (Proppe)
- SP 36: Polymerengineering (Elsner)
- SP 37: Produktionsmanagement (Deml)
- SP 38: Produktionssysteme (Schulze)
- SP 39: Produktionstechnik (Schulze)
- SP 40: Robotik (Bretthauer)
- SP 41: Strömungslehre (Frohnapfel)
- SP 43: Technische Keramik und Pulverwerkstoffe (Hoffmann)
- SP 44: Technische Logistik (Furmans)
- SP 45: Technische Thermodynamik (Maas)
- SP 46: Thermische Turbomaschinen (Bauer)
- SP 47: Tribologie (Gumbsch)
- SP 49: Zuverlässigkeit im Maschinenbau (Gumbsch)
- SP 50: Bahnsystemtechnik (Gratzfeld)
- SP 51: Entwicklung innovativer Geräte (Matthiesen)
- SP 52: Production Engineering (Deml)
- SP 53: Fusionstechnologie (Stieglitz)
- SP 54: Mikroaktoren und Mikrosensoren (Kohl)
- SP 55: Gebäudeenergietechnik (H.-M. Henning)
- SP 56: Advanced Materials Modelling (Böhlke)
- SP 57: Grundlagen des Verbrennungsmotors (Koch)
- SP 58: Verbrennungsmotorische Antriebssysteme (Koch)

## 7 Änderungshistorie (ab 29.10.2008)

|            |  |
|------------|--|
| 29.10.2008 | <p>Änderungen im Abschnitt 1.2 Module des Bachelorstudiums „B.Sc.“:</p> <ul style="list-style-type: none"> <li>- Prüfungen im Modul 1 - Höhere Mathematik: Getrennte Prüfungen zu HM I und HM II</li> <li>- Prüfungen im Modul 3 - Technische Mechanik: Getrennte Prüfungen zu TM I und TM II</li> <li>- Modul "Schwerpunkt": Umfang des Kernbereichs: 8LP, Umfang des Ergänzungsbereichs: 4 LP</li> </ul>   |
| 10.12.2008 | <p>Änderungen im Abschnitt 1.3 Studienplan des 1. Abschnitts des Bachelorstudiums „B.Sc.“</p> <ul style="list-style-type: none"> <li>- Informatik: V, Ü und P finden im ersten Semester statt</li> </ul> <p>Änderungen im Abschnitt 1.5 Masterstudium mit Vertiefungsrichtungen</p> <ul style="list-style-type: none"> <li>- „Es stehen folgende Vertiefungsrichtungen zur Auswahl“</li> </ul> <p>Änderungen im Abschnitt 2.1 Wahlpflichtfächer im Bachelor- und Masterstudiengang</p> <ul style="list-style-type: none"> <li>- Aufnahme von „Informationssysteme“ als Wahlpflichtfach für BSc, MSc, FzgT, M+M, PEK, PT</li> </ul> <p>Änderungen im Abschnitt 2.5</p> <ul style="list-style-type: none"> <li>- Umbenennung des „Allgemeinen Wahlfachs“ in „Wahlfach“</li> </ul> <p>Änderungen im Abschnitt 3.1 Fachpraktikum</p> <ul style="list-style-type: none"> <li>- Tabelle wurde durch Fließtext ersetzt</li> </ul> <p>Änderungen im Abschnitt 4 Berufspraktikum</p> <ul style="list-style-type: none"> <li>- Die Abschnitte der Fachpraktika sollen in einem geschlossenen Zeitraum durchgeführt werden</li> </ul> <p>Änderungen im Abschnitt 4.3 Sonderbestimmungen zur Anerkennung</p> <ul style="list-style-type: none"> <li>- Auf Erwerb gerichtete, berufspraktische Tätigkeiten werden nicht mehr erwähnt</li> </ul> <p>Änderungen im Abschnitt 6.1 Zuordnung der Schwerpunkte zum Bachelor- und den Vertiefungsrichtungen des Masterstudiengangs</p> <ul style="list-style-type: none"> <li>- „Informationsmanagement“ als Schwerpunkt für BSc und FzgT zugelassen</li> <li>- „Lifecycle Engineering“ als Schwerpunkt für BSc zugelassen</li> </ul> <p>Änderungen im Abschnitt 6.3 Wahlmöglichkeiten für den Schwerpunkt im „Bachelor of Science“</p> <ul style="list-style-type: none"> <li>- Aktualisierung des gesamten Schwerpunkt-Angebotes</li> </ul> |
|            | <p>Umbenennung der „Wellenphänomene in der Physik“ in Wellenphänomene in der klassischen Physik</p> <p>Abschnitt 2.1: unter (18) : „Moderne Physik für Ingenieure“ anstelle der „Physik für Ingenieure“, in Abschnitt 2.1 keine Nennung der Dozenten</p> <p>Abschnitt 2.3: unter (11) : „Grundlagen der modernen Physik“ anstelle der „Höheren Physik für Maschinenbauer“</p> <p>Einfügung einer Zwischenüberschrift 6.4 mit entsprechender Änderung des Inhaltsverzeichnisses</p>   |
| 03.02.2010 | <p>Änderungen von Veranstaltungen in den Abschnitten 2.1 bis 2.4</p> <p>Änderung im Punkt 6.1</p> <ul style="list-style-type: none"> <li>- Schwerpunkt 50 „Bahnsystemtechnik“ in Tabelle „Schwerpunkte“ eingefügt.</li> </ul> <p>Änderung im Punkt 6.2</p> <ul style="list-style-type: none"> <li>- 2. Absatz ergänzt um den Satz: „Stehen mehrere Wahlpflichtfächer (WP) als Auswahlmöglichkeit zur Verfügung, muss nur ein Wahlpflichtfach belegt werden.“</li> </ul> <p>Änderungen im Punkt 6.4</p> <ul style="list-style-type: none"> <li>- Schwerpunkttabellen ergänzt um die Spalten „Veranstaltungsnummer (VNr)“ und „Leistungspunkte (LP)“. Aktuell vorhandene Daten wurden eingefügt.</li> <li>- Einfügungen und Streichungen von Veranstaltungen in den Schwerpunkten</li> <li>- Schwerpunkt 50 „Bahnsystemtechnik“ eingefügt</li> </ul>   |
| 07.07.2010 | <p>Änderungen im Abschnitt 1.1:</p> <p>Ergänzung der Prüfungsmodalitäten</p> <p>Änderungen im Abschnitt 1.2:</p> <p>Umbenennung des „Workshops Teamkonstruktion“ in „Konstruieren im Team“;</p> <p>Bemerkung zu Erfolgskontrollen in Zusatzmodulen im Bachelorstudium</p> <p>Änderungen im Abschnitt 1.4:</p> <p>Die Bachelorarbeit ist im Anschluss an den ersten Abschnitt zu absolvieren.</p> <p>Änderungen im Abschnitt 1.5:</p> <p>Bemerkung zu Erfolgskontrollen in Zusatzmodulen im Masterstudium</p> <p>Änderungen im Abschnitt 2.1:</p> <p>Für manche Schwerpunkte kann die Wahl eines Wahlpflichtfachs empfohlen sein.</p> <p>Aktualisierung der wählbaren Wahlpflichtfächer</p> <p>Änderungen im Abschnitt 2.3 und 2.4:</p> <p>Aktualisierung der wählbaren Wahlfächer</p> <p>Änderungen im Abschnitt 4.1:</p> <p>Grundpraktikum auch an Universitäten und vergleichbaren Einrichtungen möglich</p> <p>Änderungen im Abschnitt 6.1 und 6.2:</p>   |

Studienplan der Fakultät für Maschinenbau für den Bachelor- und Masterstudiengang Maschinenbau. Gültig ab 01.10.2014, auf Beschlussfassung des Fakultätsrats am 16.07.2014 mit redaktionellen Änderungen vom 01.08.2014.

Seite 17 von 18

|            |   |
|------------|---|
|            | <p>Zusätzliche Erläuterung zur vertiefungsrichtungsspezifischen Schwerpunktwahl;<br/>                 Maximaler Umfang des Schwerpunkts im Bachelorstudium: 16 statt 14 LP<br/>                 Änderungen im Abschnitt 6.3 und 6.4:<br/>                 Überarbeitung der Formulierungen und Anpassung von SWS an LP<br/>                 Aktualisierung der wählbaren Wahlpflichtfächer<br/>                 Änderungen im Abschnitt 6.4:<br/>                 Aktualisierung des Schwerpunktangebotes</p>   |
| 29.06.2011 | <p>Änderungen im Abschnitt 1.4.: Ergänzung zu Durchführung<br/>                 Änderungen im Abschnitt 1.5.: Anpassung der Module<br/>                 Änderungen im Abschnitt 2.1.: Aktualisierung der Wahlpflichtfächer<br/>                 Änderungen im Abschnitt 2.3.: Aktualisierung der wählbaren Wahlpflichtfächer<br/>                 Änderungen im Abschnitt 4: Inhaltliche Anpassungen<br/>                 Änderungen im Abschnitt 4.1.: Inhaltliche Anpassung<br/>                 Änderungen im Abschnitt 4.2.: Inhaltliche Anpassung<br/>                 Änderungen im Abschnitt 6.4: Aktualisierung des Schwerpunktangebotes</p>  |
| 20.06.2012 | <p>Änderung im Abschnitt 2.4 (Wahlfach Wirtschaft /Recht): Die wählbare Fächer sind nun nicht mehr hier sondern im Modulhandbuch aufgeführt.<br/>                 Änderung in den Abschnitten 4. und 4.1 und 4.2 (Berufspraktikum): Inhaltliche Anpassung</p>   |
| 24.10.2012 | <p>Änderung im Abschnitt 2.3 (Wahlfach Naturwissenschaften/Informatik/Elektrotechnik): Die wählbare Fächer sind nun nicht mehr hier, sondern im Modulhandbuch aufgeführt.<br/>                 Änderungen im Abschnitt 2.1: Aktualisierung der Wahlpflichtfächer<br/>                 Änderungen im Abschnitt 6.4: Aktualisierung des Schwerpunktangebotes (SP 14 gelöscht)<br/>                 Änderungen der Zuordnungen zur Vertiefungsrichtung Produktionstechnik<br/>                 Umbenennung der Vertiefungsrichtung "Unspezifischer Master Maschinenbau" in "Allgemeiner Maschinenbau"</p>  |
| 17.07.2013 | <p>Abschnitt 1.1: Regelung der Wiederholungsprüfungen für Erfolgskontrollen anderer Art.<br/>                 Änderung in Abschnitt 2 und 3 (Wahlfach, Mathematische Methoden, Fachpraktikum): Die wählbare Fächer sind nun nicht mehr hier, sondern im Modulhandbuch aufgeführt.<br/>                 Änderung in Abschnitt 2.1: Aktualisierung der Wahlpflichtfächer; Im Masterstudiengang kann ein Wahlpflichtfach aus der Liste der wählbaren Veranstaltungen für das Wahlfach (2.5) gewählt werden.<br/>                 Präzisierung zum Veranstaltungswechsel in den Abschnitten 2.3, 2.4 und 3.<br/>                 Abschnitt 4.2: Konkretisierungen zu Bericht und Fehltagen im Berufspraktikum<br/>                 Änderung der Prüfungsdauer für schriftliche Prüfungen des Wahlpflichtfachs<br/>                 Aktualisierung des Schwerpunktangebotes (SP 42 gelöscht) und der Modulverantwortlichen<br/>                 Umbenennung der „Wellenphänomene in der klassischen Physik“ in "Wellenphänomene in der Physik"</p> |
| 01.08.2014 | <p>Änderung der Prüfungsmodalitäten in Abschnitt 1.2 (Betriebliche Produktionswirtschaft)<br/>                 Änderung des Curriculums in Abschnitt 1.3 (Betriebliche Produktionswirtschaft, Arbeitstechniken im Maschinenbau)<br/>                 Ergänzung im Wahlpflichtfachkatalog in Kapitel 2 (SP 29 wurde gelöscht)<br/>                 Möglichkeit der Wahl anderer Veranstaltungen für die Wahlfächer Naturwissenschaft/Informatik/Elektrotechnik und Wirtschaft/Recht (Abschnitt 2.2, 2.3)<br/>                 Überarbeitung der Schwerpunkte (Abschnitt 6.1): SP 7 und SP 48 wurden gelöscht, SP 54 bis 58 neu hinzugefügt<br/>                 Änderungen im Abschnitt 6.3: Inhaltliche Anpassung (Beschränkung der maximalen Anzahl der LP in den SP wurde aufgehoben)</p>   |

## 2 Learning Outcomes

### Learning Outcomes (M.Sc., Mechanical Engineering, KIT), 06/28/2013

Graduates of the Master's degree program in mechanical engineering at KIT are able to participate independently in value-added processes in engineering and contribute through their research-oriented education to science. They are especially qualified for a responsible position in industry, science and technical services and acquire qualifications that allow to pursue doctoral studies.

Graduates acquire broad and in-depth knowledge of engineering fundamentals. This is ensured by a compulsory area, which includes mathematical methods of engineering, modeling and simulation as well as the processes of product development and production. As a result, they are able to deal independently with the state of research and to further refine methods. They can develop, evaluate and interpret comprehensive and interdisciplinary simulation studies. From their understanding of market demand and value-added processes, they are able to develop products of mechanical engineering. The methods and practices that are used can be reflected and adapted to changing conditions in order to optimize the own approach.

In the specialization area, consisting of two major fields and associated electives, graduates acquire comprehensive and detailed knowledge of selected areas of mechanical engineering. Research-oriented competence is developed in an internship in the research laboratories of KIT. Graduates are thus qualified to play an important role in complex research and development projects as well as to participate competently in the innovation process and are professionally prepared for future leadership roles.

In other, even non-technical electives, students acquire further skills in self-selected subjects of natural sciences and economics. They are, inter alia, in a position to make well thought out decisions, taking into account social, economic and ethical constraints. In an industrial internship, they have tested and reinforced their skills and knowledge in the business environment.

Graduates of the Master's program in mechanical engineering at KIT have broad and in-depth knowledge. This solid foundation enables them to analyze and synthesize complex systems. They can also develop, reflect, evaluate and shape independently and sustainably systems and processes of mechanical engineering, taking into account technical, social, economic and ethical constraints. They deal constructively with their own and with others' views and present their work results in an understandable form.

Graduates are able to independently identify tasks, to obtain the information necessary to their solution, to select methods, to acquire skills and thus to contribute to added value.

## 3 Module

### 3.1 Wahlpflichtfach

#### Module: Compulsory Elective Subject General Mechanical Engineering [MSc-Modul AM, WPF AM]

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

| ECTS Credits | Cycle | Duration |
|--------------|-------|----------|
| 5            |       |          |

| ID      | Course  | Term | Lecturer                                   |
|---------|---|------|--|
| 2109035 | Human Factors Engineering I (p. 75)                             | W    | B. Deml                                    |
| 2105011 | Introduction into Mechatronics (p. 118)                         | W    | G. Bretthauer, A. Albers                   |
| 2114093 | Fluid Technology (p. 155)                                       | W    | M. Geimer, M. Scherer                      |
| 2162235 | Introduction into the multi-body dynamics (p. 119)              | S    | W. Seemann                                 |
| 2161206 | Mathematical Methods in Dynamics (p. 235)                       | W    | C. Proppe                                  |
| 2161254 | Mathematical Methods in Strength of Materials (p. 236)          | W    | T. Böhlke                                  |
| 2162241 | Mathematical methods of vibration theory (p. 238)               | S    | W. Seemann                                 |
| 2154432 | Mathematical Methods in Fluid Mechanics (p. 239)                | S    | A. Class, B. Frohnappel                    |
| 2162280 | Mathematical Methods in Structural Mechanics (p. 240)           | S    | T. Böhlke                                  |
| 2141861 | Introduction to Microsystem Technology I (p. 176)               | W    | A. Guber                                   |
| 2142874 | Introduction to Microsystem Technology II (p. 177)              | S    | A. Guber                                   |
| 2181612 | Physical basics of laser technology (p. 293)                    | W    | J. Schneider                               |
| 4040311 | Modern Physics for Engineers (p. 270)                           | S    | B. Pilawa                                  |
| 2142890 | Physics for Engineers (p. 292)                                  | S    | P. Gumbsch, A. Nesterov-Müller, D. Weygand |
| 2121350 | Product Lifecycle Management (p. 307)                           | W    | J. Ovtcharova                              |
| 2149605 | Simulation of production systems and processes (p. 346)         | W    | K. Furmans, V. Schulze, P. Stock           |
| 2117059 | Mathematical models and methods for Production Systems (p. 243) | W    | K. Furmans, J. Stoll                       |
| 2174576 | Systematic Materials Selection (p. 362)                         | S    | J. Hoffmeister                             |
| 2165512 | Heat and mass transfer (p. 399)                                 | W    | H. Bockhorn, U. Maas                       |
| 2121001 | Integrated Information Systems for engineers (p. 368)           | S    | J. Ovtcharova                              |
| 2183703 | Modelling and Simulation (p. 267)                               | W/S  | B. Nestler, P. Gumbsch                     |
| 2181738 | Scientific computing for Engineers (p. 409)                     | W    | D. Weygand, P. Gumbsch                     |
| 2183702 | Modelling of Microstructures (p. 261)                           | W    | A. August, B. Nestler, D. Weygand          |
| 2147175 | CAE-Workshop (p. 99)  | W/S  | A. Albers, Assistenten                     |
| 2165515 | Fundamentals of Combustion I (p. 182)                           | W    | U. Maas                                    |
| 2117095 | Basics of Technical Logistics (p. 181)                          | W    | M. Mittwollen, Madzharov                   |
| 2161224 | Machine Dynamics (p. 228)                                       | S    | C. Proppe                                  |
| 2161212 | Vibration Theory (p. 369)                                       | W    | A. Fidlin                                  |
| 2133103 | Fundamentals of Combustion Engines I (p. 184)                   | W    | H. Kubach, T. Koch                         |
| 2141865 | Novel actuators and sensors (p. 276)                            | W    | M. Kohl, M. Sommer                         |

**Learning Control / Examinations**

written or oral exam, graded

**Conditions**

See Studienplan

**Learning Outcomes**

The elective course serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.

The specific learning outcomes are defined by the respective coordinator of the course.

**Content**

see chosen compulsory elective subject

**Remarks**

In total, four compulsory elective subjects have to be chosen, one in the bachelor's program and three in the master's program. For the master's program, a reduced catalogue exists for every specialization (see Studienplan).

**Module: Compulsory Elective Subject E+U [MSc-Modul E+U, WPF E+U]**

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

| ECTS Credits | Cycle | Duration |
|--------------|-------|----------|
| 5            |       |          |

| ID      | Course   | Term | Lecturer                                   |
|---------|--|------|--|
| 2105011 | Introduction into Mechatronics (p. 118)            | W    | G. Bretthauer, A. Albers                   |
| 2114093 | Fluid Technology (p. 155)                          | W    | M. Geimer, M. Scherer                      |
| 2162235 | Introduction into the multi-body dynamics (p. 119) | S    | W. Seemann                                 |
| 2154432 | Mathematical Methods in Fluid Mechanics (p. 239)   | S    | A. Class, B. Frohnäpfel                    |
| 2181612 | Physical basics of laser technology (p. 293)       | W    | J. Schneider                               |
| 01874   | Numerical Mathematics (p. 281)                     | S    | C. Wieners, Neuß, Rieder                   |
| 4040311 | Modern Physics for Engineers (p. 270)              | S    | B. Pilawa                                  |
| 2142890 | Physics for Engineers (p. 292)                     | S    | P. Gumbsch, A. Nesterov-Müller, D. Weygand |
| 2174576 | Systematic Materials Selection (p. 362)            | S    | J. Hoffmeister                             |
| 2165512 | Heat and mass transfer (p. 399)                    | W    | H. Bockhorn, U. Maas                       |
| 2147175 | CAE-Workshop (p. 99)                               | W/S  | A. Albers, Assistenten                     |
| 2165515 | Fundamentals of Combustion I (p. 182)              | W    | U. Maas                                    |
| 2117095 | Basics of Technical Logistics (p. 181)             | W    | M. Mittwollen, Madzharov                   |
| 2161224 | Machine Dynamics (p. 228)                          | S    | C. Proppe                                  |
| 2161212 | Vibration Theory (p. 369)                          | W    | A. Fidlin                                  |
| 2133103 | Fundamentals of Combustion Engines I (p. 184)      | W    | H. Kubach, T. Koch                         |
| 2141865 | Novel actuators and sensors (p. 276)               | W    | M. Kohl, M. Sommer                         |

**Learning Control / Examinations**

written or oral exam, graded

**Conditions**

See Studienplan

**Learning Outcomes**

The elective course serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.

The specific learning outcomes are defined by the respective coordinator of the course.

**Content**

see chosen compulsory elective subject

**Remarks**

In total, four compulsory elective subjects have to be chosen, one in the bachelor's program and three in the master's program. For the master's program, a reduced catalogue exists for every specialization (see Studienplan).

## Module: Compulsory Elective Subject FzgT [MSc-Modul FzgT, WPF FzgT]

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

**ECTS Credits**  
5

**Cycle**

**Duration**

| ID      | Course   | Term | Lecturer                                   |
|---------|--|------|--|
| 2105011 | Introduction into Mechatronics (p. 118)                | W    | G. Bretthauer, A. Albers                   |
| 23224   | Electrical Engineering II (p. 129)                     | S    | W. Menesklou                               |
| 2114093 | Fluid Technology (p. 155)                              | W    | M. Geimer, M. Scherer                      |
| 0186000 | Probability Theory and Statistics (p. 402)             | W/S  | D. Hug                                     |
| 2162235 | Introduction into the multi-body dynamics (p. 119)     | S    | W. Seemann                                 |
| 2161206 | Mathematical Methods in Dynamics (p. 235)              | W    | C. Proppe                                  |
| 2161254 | Mathematical Methods in Strength of Materials (p. 236) | W    | T. Böhlke                                  |
| 2162241 | Mathematical methods of vibration theory (p. 238)      | S    | W. Seemann                                 |
| 2154432 | Mathematical Methods in Fluid Mechanics (p. 239)       | S    | A. Class, B. Frohnäpfel                    |
| 2181612 | Physical basics of laser technology (p. 293)           | W    | J. Schneider                               |
| 01874   | Numerical Mathematics (p. 281)                         | S    | C. Wieners, Neuß, Rieder                   |
| 4040311 | Modern Physics for Engineers (p. 270)                  | S    | B. Pilawa                                  |
| 2142890 | Physics for Engineers (p. 292)                         | S    | P. Gumbsch, A. Nesterov-Müller, D. Weygand |
| 2121350 | Product Lifecycle Management (p. 307)                  | W    | J. Ovtcharova                              |
| 2174576 | Systematic Materials Selection (p. 362)                | S    | J. Hoffmeister                             |
| 2165512 | Heat and mass transfer (p. 399)                        | W    | H. Bockhorn, U. Maas                       |
| 2121001 | Integrated Information Systems for engineers (p. 368)  | S    | J. Ovtcharova                              |
| 2147175 | CAE-Workshop (p. 99)                                   | W/S  | A. Albers, Assistenten                     |
| 2165515 | Fundamentals of Combustion I (p. 182)                  | W    | U. Maas                                    |
| 2117095 | Basics of Technical Logistics (p. 181)                 | W    | M. Mittwollen, Madzharov                   |
| 2161224 | Machine Dynamics (p. 228)                              | S    | C. Proppe                                  |
| 2161212 | Vibration Theory (p. 369)                              | W    | A. Fidlin                                  |
| 2133103 | Fundamentals of Combustion Engines I (p. 184)          | W    | H. Kubach, T. Koch                         |
| 2141865 | Novel actuators and sensors (p. 276)                   | W    | M. Kohl, M. Sommer                         |

### Learning Control / Examinations

written or oral exam, graded

### Conditions

See Studienplan

### Learning Outcomes

The elective course serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.

The specific learning outcomes are defined by the respective coordinator of the course.

### Content

see chosen compulsory elective subject

### Remarks

In total, four compulsory elective subjects have to be chosen, one in the bachelor's program and three in the

master's program. For the master's program, a reduced catalogue exists for every specialization (see Studienplan).

## Module: Compulsory Elective Subject M+M [MSc-Modul M+M, WPF M+M]

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

**ECTS Credits**  
5

**Cycle**

**Duration**

| ID      | Course   | Term | Lecturer                                   |
|---------|--|------|--|
| 2105011 | Introduction into Mechatronics (p. 118)                | W    | G. Bretthauer, A. Albers                   |
| 0186000 | Probability Theory and Statistics (p. 402)             | W/S  | D. Hug                                     |
| 2162235 | Introduction into the multi-body dynamics (p. 119)     | S    | W. Seemann                                 |
| 2161206 | Mathematical Methods in Dynamics (p. 235)              | W    | C. Proppe                                  |
| 2161254 | Mathematical Methods in Strength of Materials (p. 236) | W    | T. Böhlke                                  |
| 2162241 | Mathematical methods of vibration theory (p. 238)      | S    | W. Seemann                                 |
| 2162280 | Mathematical Methods in Structural Mechanics (p. 240)  | S    | T. Böhlke                                  |
| 2141861 | Introduction to Microsystem Technology I (p. 176)      | W    | A. Guber                                   |
| 2142874 | Introduction to Microsystem Technology II (p. 177)     | S    | A. Guber                                   |
| 2181612 | Physical basics of laser technology (p. 293)           | W    | J. Schneider                               |
| 01874   | Numerical Mathematics (p. 281)                         | S    | C. Wieners, Neuß, Rieder                   |
| 4040311 | Modern Physics for Engineers (p. 270)                  | S    | B. Pilawa                                  |
| 2142890 | Physics for Engineers (p. 292)                         | S    | P. Gumbsch, A. Nesterov-Müller, D. Weygand |
| 2121350 | Product Lifecycle Management (p. 307)                  | W    | J. Ovtcharova                              |
| 2174576 | Systematic Materials Selection (p. 362)                | S    | J. Hoffmeister                             |
| 2165512 | Heat and mass transfer (p. 399)                        | W    | H. Bockhorn, U. Maas                       |
| 2121001 | Integrated Information Systems for engineers (p. 368)  | S    | J. Ovtcharova                              |
| 2147175 | CAE-Workshop (p. 99)                                   | W/S  | A. Albers, Assistenten                     |
| 2165515 | Fundamentals of Combustion I (p. 182)                  | W    | U. Maas                                    |
| 2117095 | Basics of Technical Logistics (p. 181)                 | W    | M. Mittwollen, Madzharov                   |
| 2161224 | Machine Dynamics (p. 228)                              | S    | C. Proppe                                  |
| 2161212 | Vibration Theory (p. 369)                              | W    | A. Fidlin                                  |
| 2133103 | Fundamentals of Combustion Engines I (p. 184)          | W    | H. Kubach, T. Koch                         |
| 2141865 | Novel actuators and sensors (p. 276)                   | W    | M. Kohl, M. Sommer                         |

### Learning Control / Examinations

written or oral exam, graded

### Conditions

See Studienplan

### Learning Outcomes

The elective course serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.

The specific learning outcomes are defined by the respective coordinator of the course.

### Content

see chosen compulsory elective subject

**Remarks**

In total, four compulsory elective subjects have to be chosen, one in the bachelor's program and three in the master's program. For the master's program, a reduced catalogue exists for every specialization (see Studienplan).

**Module: Compulsory Elective Subject PEK [MSc-Modul PEK, WPF PEK]**

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

**ECTS Credits**  
5

**Cycle**

**Duration**

| ID      | Course   | Term | Lecturer                 |
|---------|--|------|--------------------------|
| 2109035 | Human Factors Engineering I (p. 75)                    | W    | B. Deml                  |
| 2105011 | Introduction into Mechatronics (p. 118)                | W    | G. Bretthauer, A. Albers |
| 2114093 | Fluid Technology (p. 155)                              | W    | M. Geimer, M. Scherer    |
| 2162235 | Introduction into the multi-body dynamics (p. 119)     | S    | W. Seemann               |
| 2161206 | Mathematical Methods in Dynamics (p. 235)              | W    | C. Proppe                |
| 2161254 | Mathematical Methods in Strength of Materials (p. 236) | W    | T. Böhlke                |
| 2162241 | Mathematical methods of vibration theory (p. 238)      | S    | W. Seemann               |
| 2162280 | Mathematical Methods in Structural Mechanics (p. 240)  | S    | T. Böhlke                |
| 2141861 | Introduction to Microsystem Technology I (p. 176)      | W    | A. Guber                 |
| 2142874 | Introduction to Microsystem Technology II (p. 177)     | S    | A. Guber                 |
| 2181612 | Physical basics of laser technology (p. 293)           | W    | J. Schneider             |
| 2121350 | Product Lifecycle Management (p. 307)                  | W    | J. Ovtcharova            |
| 2174576 | Systematic Materials Selection (p. 362)                | S    | J. Hoffmeister           |
| 2165512 | Heat and mass transfer (p. 399)                        | W    | H. Bockhorn, U. Maas     |
| 2121001 | Integrated Information Systems for engineers (p. 368)  | S    | J. Ovtcharova            |
| 2147175 | CAE-Workshop (p. 99)                                   | W/S  | A. Albers, Assistenten   |
| 2117095 | Basics of Technical Logistics (p. 181)                 | W    | M. Mittwollen, Madzharov |
| 2161224 | Machine Dynamics (p. 228)                              | S    | C. Proppe                |
| 2161212 | Vibration Theory (p. 369)                              | W    | A. Fidlin                |
| 2133103 | Fundamentals of Combustion Engines I (p. 184)          | W    | H. Kubach, T. Koch       |
| 2141865 | Novel actuators and sensors (p. 276)                   | W    | M. Kohl, M. Sommer       |

**Learning Control / Examinations**

written or oral exam, graded

**Conditions**

See Studienplan

**Learning Outcomes**

The elective course serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.

The specific learning outcomes are defined by the respective coordinator of the course.

**Content**

see chosen compulsory elective subject

**Remarks**

In total, four compulsory elective subjects have to be chosen, one in the bachelor's program and three in the master's program. For the master's program, a reduced catalogue exists for every specialization (see Studienplan).

## Module: Compulsory Elective Subject PT [MSc-Modul PT, WPF PT]

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

**ECTS Credits**  
5

**Cycle**

**Duration**

| ID      | Course  | Term | Lecturer                         |
|---------|---|------|----------------------------------|
| 2109035 | Human Factors Engineering I (p. 75)                             | W    | B. Deml                          |
| 2105011 | Introduction into Mechatronics (p. 118)                         | W    | G. Bretthauer, A. Albers         |
| 2114093 | Fluid Technology (p. 155)                                       | W    | M. Geimer, M. Scherer            |
| 2162235 | Introduction into the multi-body dynamics (p. 119)              | S    | W. Seemann                       |
| 2161254 | Mathematical Methods in Strength of Materials (p. 236)          | W    | T. Böhlke                        |
| 2141861 | Introduction to Microsystem Technology I (p. 176)               | W    | A. Guber                         |
| 2142874 | Introduction to Microsystem Technology II (p. 177)              | S    | A. Guber                         |
| 2181612 | Physical basics of laser technology (p. 293)                    | W    | J. Schneider                     |
| 01874   | Numerical Mathematics (p. 281)                                  | S    | C. Wieners, Neuß, Rieder         |
| 2121350 | Product Lifecycle Management (p. 307)                           | W    | J. Ovtcharova                    |
| 2149605 | Simulation of production systems and processes (p. 346)         | W    | K. Furmans, V. Schulze, P. Stock |
| 2117059 | Mathematical models and methods for Production Systems (p. 243) | W    | K. Furmans, J. Stoll             |
| 2174576 | Systematic Materials Selection (p. 362)                         | S    | J. Hoffmeister                   |
| 2121001 | Integrated Information Systems for engineers (p. 368)           | S    | J. Ovtcharova                    |
| 2183703 | Modelling and Simulation (p. 267)                               | W/S  | B. Nestler, P. Gumbsch           |
| 2147175 | CAE-Workshop (p. 99)  | W/S  | A. Albers, Assistenten           |
| 2117095 | Basics of Technical Logistics (p. 181)                          | W    | M. Mittwollen, Madzharov         |
| 2161224 | Machine Dynamics (p. 228)                                       | S    | C. Proppe                        |
| 2161212 | Vibration Theory (p. 369)                                       | W    | A. Fidlin                        |
| 2141865 | Novel actuators and sensors (p. 276)                            | W    | M. Kohl, M. Sommer               |

### Learning Control / Examinations

written or oral exam, graded

### Conditions

See Studienplan

### Learning Outcomes

The elective course serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.

The specific learning outcomes are defined by the respective coordinator of the course.

### Content

see chosen compulsory elective subject

### Remarks

In total, four compulsory elective subjects have to be chosen, one in the bachelor's program and three in the master's program. For the master's program, a reduced catalogue exists for every specialization (see Studienplan).

## Module: Compulsory Elective Subject ThM [MSc-Modul ThM, WPF ThM]

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

**ECTS Credits**  
5

**Cycle**

**Duration**

| ID      | Course  | Term | Lecturer                                   |
|---------|---|------|--|
| 2114093 | Fluid Technology (p. 155)                                       | W    | M. Geimer, M. Scherer                      |
| 0186000 | Probability Theory and Statistics (p. 402)                      | W/S  | D. Hug                                     |
| 2162235 | Introduction into the multi-body dynamics (p. 119)              | S    | W. Seemann                                 |
| 2161206 | Mathematical Methods in Dynamics (p. 235)                       | W    | C. Proppe                                  |
| 2161254 | Mathematical Methods in Strength of Materials (p. 236)          | W    | T. Böhlke                                  |
| 2162241 | Mathematical methods of vibration theory (p. 238)               | S    | W. Seemann                                 |
| 2154432 | Mathematical Methods in Fluid Mechanics (p. 239)                | S    | A. Class, B. Frohnäpfel                    |
| 2162280 | Mathematical Methods in Structural Mechanics (p. 240)           | S    | T. Böhlke                                  |
| 01874   | Numerical Mathematics (p. 281)                                  | S    | C. Wieners, Neuß, Rieder                   |
| 4040311 | Modern Physics for Engineers (p. 270)                           | S    | B. Pilawa                                  |
| 2142890 | Physics for Engineers (p. 292)                                  | S    | P. Gumbsch, A. Nesterov-Müller, D. Weygand |
| 2117059 | Mathematical models and methods for Production Systems (p. 243) | W    | K. Furmans, J. Stoll                       |
| 2174576 | Systematic Materials Selection (p. 362)                         | S    | J. Hoffmeister                             |
| 2165512 | Heat and mass transfer (p. 399)                                 | W    | H. Bockhorn, U. Maas                       |
| 2183703 | Modelling and Simulation (p. 267)                               | W/S  | B. Nestler, P. Gumbsch                     |
| 2181738 | Scientific computing for Engineers (p. 409)                     | W    | D. Weygand, P. Gumbsch                     |
| 2183702 | Modelling of Microstructures (p. 261)                           | W    | A. August, B. Nestler, D. Weygand          |
| 2165515 | Fundamentals of Combustion I (p. 182)                           | W    | U. Maas                                    |
| 2117095 | Basics of Technical Logistics (p. 181)                          | W    | M. Mittwollen, Madzharov                   |
| 2161224 | Machine Dynamics (p. 228)                                       | S    | C. Proppe                                  |
| 2161212 | Vibration Theory (p. 369)                                       | W    | A. Fidlin                                  |

### Learning Control / Examinations

written or oral exam, graded

### Conditions

See Studienplan

### Learning Outcomes

The elective course serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.

The specific learning outcomes are defined by the respective coordinator of the course.

### Content

see chosen compulsory elective subject

### Remarks

In total, four compulsory elective subjects have to be chosen, one in the bachelor's program and three in the master's program. For the master's program, a reduced catalogue exists for every specialization (see Studienplan).

**Module: Compulsory Elective Subject W+S [MSc-Modul W+S, WPF W+S]**

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

**ECTS Credits**  
5

**Cycle**

**Duration**

| ID      | Course   | Term | Lecturer                                   |
|---------|--|------|--|
| 2162235 | Introduction into the multi-body dynamics (p. 119)     | S    | W. Seemann                                 |
| 2161254 | Mathematical Methods in Strength of Materials (p. 236) | W    | T. Böhlke                                  |
| 2162280 | Mathematical Methods in Structural Mechanics (p. 240)  | S    | T. Böhlke                                  |
| 2181612 | Physical basics of laser technology (p. 293)           | W    | J. Schneider                               |
| 4040311 | Modern Physics for Engineers (p. 270)                  | S    | B. Pilawa                                  |
| 2142890 | Physics for Engineers (p. 292)                         | S    | P. Gumbsch, A. Nesterov-Müller, D. Weygand |
| 2174576 | Systematic Materials Selection (p. 362)                | S    | J. Hoffmeister                             |
| 2183703 | Modelling and Simulation (p. 267)                      | W/S  | B. Nestler, P. Gumbsch                     |
| 2181738 | Scientific computing for Engineers (p. 409)            | W    | D. Weygand, P. Gumbsch                     |
| 2183702 | Modelling of Microstructures (p. 261)                  | W    | A. August, B. Nestler, D. Weygand          |
| 2147175 | CAE-Workshop (p. 99)                                   | W/S  | A. Albers, Assistenten                     |
| 2117095 | Basics of Technical Logistics (p. 181)                 | W    | M. Mittwollen, Madzharov                   |
| 2161224 | Machine Dynamics (p. 228)                              | S    | C. Proppe                                  |
| 2161212 | Vibration Theory (p. 369)                              | W    | A. Fidlin                                  |

**Learning Control / Examinations**

written or oral exam, graded

**Conditions**

See Studienplan

**Learning Outcomes**

The elective course serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.

The specific learning outcomes are defined by the respective coordinator of the course.

**Content**

see chosen compulsory elective subject

**Remarks**

In total, four compulsory elective subjects have to be chosen, one in the bachelor's program and three in the master's program. For the master's program, a reduced catalogue exists for every specialization (see Studienplan).

### 3.2 Wahlfach

#### Module: Elective Subject [MSc-Modul 04, WF]

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

| ECTS Credits | Cycle | Duration |
|--------------|-------|----------|
| 4            |       |          |

| ID      | Course   | Term | Lecturer                          |
|---------|--|------|-----------------------------------|
| 2134150 | Analysis of Exhaust Gas und Lubricating Oil in Combustion Engines (p. 64)          | S    | M. Gohl                           |
| 2105012 | Adaptive Control Systems (p. 65)   | W    | G. Bretthauer                     |
| 2154420 | Aerodynamics (p. 66)   | S    | F. Ohle                           |
| 2154436 | Aerothermodynamics (p. 67)   | S    | F. Seiler                         |
| 2117059 | Mathematical models and methods for Production Systems (p. 243)                    | W    | K. Furmans, J. Stoll              |
| 2145181 | Applied Tribology in Industrial Product Development (p. 68)                        | W    | A. Albers, W. Burger              |
| 2181614 | Applied Materials Modelling (p. 69)  | S    | P. Gumbsch, B. Nestler, A. August |
| 2113077 | Drive Train of Mobile Machines (p. 70)   | W    | M. Geimer, M. Scherer             |
| 2117064 | Application of technical logistics in modern crane systems (p. 71)                 | W    | M. Golder                         |
| 2118089 | Application of technical logistics in sorting- and distribution technology (p. 72) | S    | J. Föllner                        |
| 2182735 | Application of advanced programming languages in mechanical engineering (p. 73)    | S    | D. Weygand                        |
| 2109035 | Human Factors Engineering I (p. 75)  | W    | B. Deml                           |
| 2109036 | Human Factors Engineering II (p. 77)   | W    | B. Deml                           |
| 2181740 | Atomistic simulations and molecular dynamics (p. 78)                               | S    | P. Gumbsch                        |
| 2194643 | Constitution and Properties of Wear resistant materials (p. 79)                    | S    | S. Ulrich                         |
| 2177601 | Constitution and Properties of Protective Coatings (p. 80)                         | W    | S. Ulrich                         |
| 2190411 | Selected Problems of Applied Reactor Physics and Exercises (p. 86)                 | S    | R. Dagan                          |
| 2118087 | Selected Applications of Technical Logistics (p. 81)                               | S    | M. Mittwollen, Madzharov          |
| 2170454 | Selected Topics in Aeronautics and Astronautics I (p. 82)                          | S    | S. Wittig                         |
| 2169486 | Selected Topics in Aeronautics and Astronautics II (p. 83)                         | W    | S. Wittig                         |
| 2143892 | Selected Topics on Optics and Microoptics for Mechanical Engineers (p. 84)         | W/S  | T. Mappes                         |
| 2167541 | Selected chapters of the combustion fundamentals (p. 85)                           | W/S  | U. Maas                           |
| 2181745 | Design of highly stresses components (p. 87)                                       | W    | J. Aktaa                          |
| 2113079 | Design and Development of Mobile Machines (p. 88)                                  | W    | M. Geimer, J. Siebert             |
| 2146208 | Dimensioning and Optimization of Power Train System (p. 89)                        | S    | E. Kirchner                       |
| 2106005 | Automation Systems (p. 90)   | S    | M. Kaufmann                       |
| 2115919 | Rail System Technology (p. 92)   | W/S  | P. Gratzfeld                      |

| ID      | Course   | Term | Lecturer                                  |
|---------|--|------|---|
| 2133108 | Fuels and Lubricants for Combustion Engines (p. 94)                            | W    | B. Kehrwald                               |
| 2141864 | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I (p. 95)   | W    | A. Guber                                  |
| 2142883 | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II (p. 96)  | S    | A. Guber                                  |
| 2142879 | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III (p. 97) | S    | A. Guber                                  |
| 2114092 | BUS-Controls (p. 98)   | S    | M. Geimer                                 |
| 2147175 | CAE-Workshop (p. 99)   | W/S  | A. Albers, Assistenten                    |
| 2130910 | CFD for Power Engineering (p. 100)   | S    | I. Otic                                   |
| 2106004 | Computational Intelligence I (p. 102)  | S    | G. Bretthauer, R. Mikut                   |
| 2105015 | Computational Intelligence II (p. 103)   | W    | G. Bretthauer, R. Mikut                   |
| 2106020 | Computational Intelligence III (p. 104)  | S    | R. Mikut                                  |
| 2137309 | Digital Control (p. 108)   | W    | M. Knoop                                  |
| 2161229 | Designing with numerical methods in product development (p. 109)               | W    | E. Schnack                                |
| 2162255 | Designing with composites (p. 110)   | S    | E. Schnack                                |
| 2163111 | Dynamics of the Automotive Drive Train (p. 111)                                | W    | A. Fidlin                                 |
| 3110041 | Introduction in Human Factors Engineering (p. 112)                             | S    | B. Deml                                   |
| 2113102 | Introduction to Automotive Lightweight Technology (p. 145)                     | W    | F. Henning                                |
| 2162282 | Introduction to the Finite Element Method (p. 113)                             | S    | T. Böhlke                                 |
| 2182732 | Introduction to Theory of Materials (p. 116)                                   | S    | M. Kamlah                                 |
| 2178734 | Introduction to the Mechanics of Composite Materials (p. 117)                  | S    | Y. Yang                                   |
| 2105011 | Introduction into Mechatronics (p. 118)  | W    | G. Bretthauer, A. Albers                  |
| 2162235 | Introduction into the multi-body dynamics (p. 119)                             | S    | W. Seemann                                |
| 2154430 | Introduction to modeling of aerospace systems (p. 120)                         | S    | G. Schlöffel                              |
| 2161226 | Introduction to numerical mechanics (p. 121)                                   | W    | E. Schnack                                |
| 2162247 | Introduction to Nonlinear Vibrations (p. 122)                                  | S    | A. Fidlin                                 |
| 2114346 | Electric Rail Vehicles (p. 128)  | S    | P. Gratzfeld                              |
| 2117096 | Elements of Technical Logistics (p. 130)                                       | W    | M. Mittwollen, Madzharov                  |
| 2117097 | Elements of Technical Logistics and Project (p. 131)                           | W    | M. Mittwollen, Madzharov                  |
| 2170832 | Energy and Process Technology II (p. 133)                                      | S    | C. Höfler, H. Wirbser                     |
| 2157961 | Energy and Process Technology I (p. 132)                                       | W    | H. Bauer, A. Velji, H. Wirbser, C. Höfler |
| 2117500 | Energy efficient intralogistic systems (p. 134)                                | W    | F. Schönung                               |
| 2129901 | Energy Systems I: Renewable Energy (p. 135)                                    | W    | R. Dagan                                  |
| 2130921 | Energy Systems II: Nuclear Energy and Reactor Technology (p. 136)              | S    | A. Badea                                  |
| 2106008 | Organ support systems (p. 137)   | S    | C. Pylatiuk                               |
| 2154446 | Experimental Fluid Mechanics (p. 138)  | S    | J. Kriegseis                              |
| 2113807 | Handling Characteristics of Motor Vehicles I (p. 141)                          | W    | H. Unrau                                  |
| 2114838 | Handling Characteristics of Motor Vehicles II (p. 142)                         | S    | H. Unrau                                  |
| 2113806 | Vehicle Comfort and Acoustics I (p. 143)                                       | W    | F. Gauterin                               |
| 2114825 | Vehicle Comfort and Acoustics II (p. 144)                                      | S    | F. Gauterin                               |
| 2113816 | Vehicle Mechatronics I (p. 146)  | W    | D. Ammon                                  |
| 2138340 | Automotive Vision (p. 148)   | S    | C. Stiller, M. Lauer                      |
| 2114053 | Composites for Lightweight Design (p. 149)                                     | S    | F. Henning                                |

| ID      | Course  | Term | Lecturer   |
|---------|---|------|--|
| 2183716 | FEM Workshop – constitutive laws (p. 150)   | W/S  | K. Schulz, D. Weygand                            |
| 2143882 | Fabrication Processes in Microsystem Technology (p. 151)                              | W/S  | K. Bade  |
| 2193003 | Solid State Reactions and Kinetics of Phase Transformations (with exercises) (p. 152) | W    | P. Franke, K. Krüger                             |
| 2154431 | Finite Volume Methods for Fluid Flow (p. 153)   | S    | C. Günther                                       |
| 2154401 | Fluid-Structure-Interaction (p. 154)  | S    | M. Mühlhausen                                    |
| 2114093 | Fluid Technology (p. 155)   | W    | M. Geimer, M. Scherer                            |
| 3165016 | Fundamentals of Combustion I (p. 156)   | W    | U. Maas, A. Goldman                              |
| 2126784 | Functional Ceramics (p. 157)  | S    | M. Hoffmann, M. Bäurer                           |
| 2169483 | Fusion Technology A (p. 158)  | W    | R. Stieglitz                                     |
| 2190492 | Fusion Technology B (p. 159)  | S    | R. Stieglitz                                     |
| 2134141 | Gas Engines (p. 162)  | S    | R. Golloch                                       |
| 2170490 | Combined Cycle Power Plants (p. 160)  | S    | T. Schulenberg                                   |
| 2114850 | Global vehicle evaluation within virtual road test (p. 163)                           | S    | B. Schick  |
| 2174575 | Foundry Technology (p. 164)   | S    | C. Wilhelm                                       |
| 2149610 | Global Production and Logistics - Part 1: Global Production (p. 165)                  | W    | G. Lanza   |
| 2149600 | Global Production and Logistics - Part 2: Global Logistics (p. 167)                   | S    | K. Furmans                                       |
| 2181744 | Size effects in micro and nanostructures materials (p. 169)                           | W    | P. Gumbsch, D. Weygand, P. Gruber, M. Dienwiebel |
| 2130927 | Fundamentals of Energy Technology (p. 170)  | S    | A. Badea   |
| 2113805 | Automotive Engineering I (p. 171)   | W    | F. Gauterin, H. Unrau                            |
| 2114835 | Automotive Engineering II (p. 172)  | S    | F. Gauterin, H. Unrau                            |
| 2193010 | Grundlagen der Herstellungsverfahren der Keramik und Pulvermetallurgie (p. 173)       | W    | R. Oberacker                                     |
| 2134138 | Fundamentals of catalytic exhaust gas aftertreatment (p. 174)                         | S    | E. Lox   |
| 2105992 | Principles of Medicine for Engineers (p. 175)   | W    | C. Pylatiuk                                      |
| 2141861 | Introduction to Microsystem Technology I (p. 176)                                     | W    | A. Guber   |
| 2142874 | Introduction to Microsystem Technology II (p. 177)                                    | S    | A. Guber   |
| 2181720 | Foundations of nonlinear continuum mechanics (p. 178)                                 | W    | M. Kamlah  |
| 2141007 | Fundamentals of X-ray Optics I (p. 180)   | W    | A. Last  |
| 2117095 | Basics of Technical Logistics (p. 181)  | W    | M. Mittwollen, Madzharov                         |
| 2165515 | Fundamentals of Combustion I (p. 182)   | W    | U. Maas  |
| 2166538 | Fundamentals of combustion II (p. 183)  | S    | U. Maas  |
| 2133103 | Fundamentals of Combustion Engines I (p. 184)   | W    | H. Kubach, T. Koch                               |
| 2134131 | Fundamentals of Combustion Engines II (p. 185)  | S    | H. Kubach, T. Koch                               |
| 2153410 | Optical Flow Measurement: Fundamentals and Applications (p. 186)                      | W    | F. Seiler  |
| 2114845 | Basics and Methods for Integration of Tires and Vehicles (p. 147)                     | S    | G. Leister                                       |
| 2174600 | High Temperature Structural Materials (p. 188)  | W    | M. Heilmaier                                     |
| 2106040 | Human Biology (p. 189)  | S    | C. Pylatiuk                                      |
| 2157432 | Hydraulic Fluid Machinery I (Basics) (p. 190)   | W    | M. Gabi  |
| 2158105 | Hydraulic Fluid Machinery II (p. 191)   | S    | S. Caglar, M. Gabi                               |
| 2154437 | Hydrodynamic Stability: From Order to Chaos (p. 192)                                  | S    | A. Class   |
| 2153425 | Industrial aerodynamics (p. 193)  | W    | T. Breitling                                     |
| 2109042 | Introduction to Industrial Production Economics (p. 194)                              | W    | S. Dürrschnabel                                  |

| ID      | Course  | Term | Lecturer                            |
|---------|---|------|-------------------------------------|
| 2110037 | Occupational Safety and Environmental Protection (in German) (p. 195)                         | S    | R. von Kiparski                     |
| 2118094 | Information Systems in Logistics and Supply Chain Management (p. 197)                         | S    | C. Kilger                           |
| 2130973 | Innovative Nuclear Systems (p. 199)   | S    | X. Cheng                            |
| 2114914 | Railways in the Transportation Market (p. 106)  | S    | P. Gratzfeld                        |
| 2190490 | Introduction to Neutron Cross Section Theory and Nuclear Data Generation (p. 200)             | S    | R. Dagan                            |
| 2118183 | IT-Fundamentals of Logistics (p. 201)   | S    | F. Thomas                           |
| 2125757 | Introduction to Ceramics (p. 203)   | W    | M. Hoffmann                         |
| 2126730 | Ceramics Processing (p. 204)  | S    | J. Binder                           |
| 2170460 | Nuclear Power Plant Technology (p. 205)   | S    | T. Schulenberg, K. Litfin           |
| 2169461 | Coal fired power plants (p. 207)  | W    | P. Fritz, T. Schulenberg            |
| 2174571 | Design with Plastics (p. 208)   | S    | M. Liedel                           |
| 2114101 | Methodical Design of Composite Structures (p. 257)  | S    | O. Helms                            |
| 2174580 | Structural Materials (p. 209)   | S    | K. Lang                             |
| 2146190 | Lightweight Engineering Design (p. 210)   | S    | A. Albers, N. Burkardt              |
| 2161214 | Vibration of continuous systems (p. 211)  | S    | H. Hetzler                          |
| 2170463 | Cooling of thermally high loaded gas turbine components (p. 213)                              | S    | H. Bauer, A. Schulz                 |
| 2118097 | Warehousing and distribution systems (p. 215)   | S    | M. Schwab, J. Weiblen               |
| 2182642 | Laser in automotive engineering (p. 217)  | S    | J. Schneider                        |
| 2145184 | Leadership and Product Development (p. 218)   | W    | A. Ploch                            |
| 2118078 | Logistics - organisation, design and control of logistic systems (p. 220)                     | S    | K. Furmans                          |
| 2118085 | Automotive Logistics (p. 221)   | S    | K. Furmans                          |
| 2117056 | Airport logistics (p. 222)  | W    | A. Richter                          |
| 2137308 | Machine Vision (p. 223)   | W    | C. Stiller, M. Lauer                |
| 2153429 | Magnetohydrodynamics (p. 225)   | W    | L. Bühler                           |
| 2190496 | Magnet Technology of Fusion Reactors (p. 224)   | S    | W. Fietz, K. Weiss                  |
| 2110017 | Leadership and Conflict Management (in German) (p. 226)                                       | S    | H. Hatzl                            |
| 2162220 | Machine Dynamics II (p. 229)  | W    | C. Proppe                           |
| 2117051 | Material flow in logistic systems (p. 230)  | W    | K. Furmans                          |
| 2174601 | Materialien für elektrochemische Speicher und Wandler (p. 231)                                | S    |                                     |
| 2149669 | Materials and Processes for Body Lightweight Construction in the Automotive Industry (p. 232) | W    | D. Steegmüller, S. Kienzle          |
| 2162240 | Mathematical Foundation for Computational Mechanics (p. 234)                                  | S    | E. Schnack                          |
| 2161206 | Mathematical Methods in Dynamics (p. 235)   | W    | C. Proppe                           |
| 2162241 | Mathematical methods of vibration theory (p. 238)   | S    | W. Seemann                          |
| 2154432 | Mathematical Methods in Fluid Mechanics (p. 239)  | S    | A. Class, B. Frohnäpfel             |
| 2165525 | Mathematical models and methods in combustion theory (p. 242)                                 | W    | V. Bykov, U. Maas                   |
| 2161983 | Mechanics of laminated composites (p. 247)  | W    | E. Schnack                          |
| 2173580 | Mechanics and Strengths of Polymers (p. 248)  | W    | B. Graf von Bernstorff              |
| 2181710 | Mechanics in Microtechnology (p. 249)   | W    | P. Gruber, C. Greiner               |
| 2178120 | Mechanical Characteristics and Microstructure Characteristics Relationships (p. 250)          | S    | O. Kraft, P. Gruber                 |
| 2138326 | Measurement II (p. 252)   | S    | C. Stiller                          |
| 2174598 | Metals (p. 254)   | S    | M. Heilmaier, K. von Klinski-Wetzel |

| ID      | Course  | Term | Lecturer                                   |
|---------|---|------|--|
| 2134134 | Analysis tools for combustion diagnostics (p. 256)                              | S    | U. Wagner                                  |
| 2142884 | Microoptics and Lithography (p. 258)  | S    | T. Mappes                                  |
| 2142881 | Microactuators (p. 259)   | S    | M. Kohl                                    |
| 2161251 | Microstructure characterization and modelling (p. 260)                          | W    | T. Böhlke, F. Fritzen                      |
| 2183702 | Modelling of Microstructures (p. 261)   | W    | A. August, B. Nestler, D. Weygand          |
| 2114073 | Mobile Machines (p. 263)  | S    | M. Geimer                                  |
| 2134139 | Model based Application Methods (p. 264)  | S    | F. Kirschbaum                              |
| 2167523 | Modeling of Thermodynamical Processes (p. 266)                                  | W/S  | R. Schießl, U. Maas                        |
| 2134137 | Engine measurement techniques (p. 272)  | S    | S. Bernhardt                               |
| 2142861 | Nanotechnology for Engineers and Natural Scientists (p. 273)                    | W    | H. Hölscher, M. Dienwiebel, S. Walheim     |
| 2143876 | Nanotechnology with Clusterbeams (p. 274)                                       | W/S  | J. Gspann                                  |
| 2181712 | Nanotribology and -Mechanics (p. 275)   |      | M. Dienwiebel, H. Hölscher                 |
| 2141865 | Novel actuators and sensors (p. 276)  | W    | M. Kohl, M. Sommer                         |
| 2189473 | Neutron physics of fusion reactors (p. 277)                                     | W    | U. Fischer                                 |
| 2162298 | Numerical mechanics for industrial applications (p. 282)                        | S    | E. Schnack                                 |
| 2157441 | Computational Methods in Fluid Mechanics (p. 283)                               | W    | F. Magagnato                               |
| 2130934 | Numerical Modeling of Multiphase Flows (p. 284)                                 | S    | M. Wörner                                  |
| 2169458 | Numerical simulation of reacting two phase flows (p. 285)                       | W    | R. Koch                                    |
| 2154449 | Numerical Simulation of Turbulent Flows (p. 286)                                | S    | G. Grötzbach                               |
| 2147161 | Intellectual Property Rights and Strategies in Industrial Companies (p. 289)    | W/S  | F. Zacharias                               |
| 2142890 | Physics for Engineers (p. 292)  | S    | P. Gumbsch, A. Nesterov-Müller, D. Weygand |
| 2181612 | Physical basics of laser technology (p. 293)                                    | W    | J. Schneider                               |
| 2109034 | Planning of Assembly Systems (in German) (p. 295)                               | W    | E. Haller                                  |
| 2162344 | Nonlinear Continuum Mechanics (p. 278)  | S    | T. Böhlke                                  |
| 2122376 | PLM for Product Development in Mechatronics (p. 296)                            | S    | M. Eigner                                  |
| 2121366 | PLM in the Manufacturing Industry (p. 297)                                      | W    | G. Meier                                   |
| 2173590 | Polymer Engineering I (p. 298)  | W    | P. Elsner                                  |
| 2174596 | Polymer Engineering II (p. 299)   | S    | P. Elsner                                  |
| 2121350 | Product Lifecycle Management (p. 307)   | W    | J. Ovtcharova                              |
| 2123364 | Product, Process and Resource Integration in the Automotive Industry (p. 309)   | S    | S. Mbang                                   |
| 2109028 | Production Management I (p. 313)  | W    | P. Stock                                   |
| 2110028 | Production Management II (p. 314)   | S    | P. Stock                                   |
| 2110032 | Production Planning and Control (p. 315)  | W    | A. Rinn                                    |
| 2110046 | Productivity Management in Production Systems (p. 319)                          | S    | S. Stowasser                               |
| 2115817 | Project Workshop: Automotive Engineering (p. 321)                               | W/S  | F. Gauterin                                |
| 2149680 | Project Mikro Manufacturing: Design and Manufacturing of Micro Systems (p. 322) | W    | V. Schulze, P. Hoppen                      |
| 2113072 | Development of Oil-Hydraulic Powertrain Systems (p. 323)                        | W    | G. Geerling, I. Ays                        |
| 2115995 | Project Management in Rail Industry (p. 324)                                    | W    | P. Gratzfeld                               |

| ID      | Course  | Term | Lecturer                         |
|---------|---|------|----------------------------------|
| 2145182 | Project management in Global Product Engineering Structures (p. 325)                              | W    | P. Gutzmer                       |
| 2161501 | Process Simulation in Forming Operations (p. 326)   | W    | D. Helm                          |
| 2126749 | Advanced powder metals (p. 327)   | S    | R. Oberacker                     |
| 2149667 | Quality Management (p. 328)   | W    | G. Lanza                         |
| 2189465 | Reactor Safety I: Fundamentals (p. 331)   | S    | V. Sánchez-Espinoza              |
| 2190465 | Fundamentals of reactor safety for the operation and dismantling of nuclear power plants (p. 179) | W    | V. Sánchez-Espinoza              |
| 2162256 | Computational Vehicle Dynamics (p. 332)   | S    | C. Proppe                        |
| 2162216 | Computerized Multibody Dynamics (p. 333)  | S    | W. Seemann                       |
| 2122387 | Computer Integrated Planning of New Products (p. 334)   | S    | R. Kläger                        |
| 2161250 | Computational Mechanics I (p. 335)  | W    | T. Böhlke, T. Langhoff           |
| 2162296 | Computational Mechanics II (p. 336)   | S    | T. Böhlke, T. Langhoff           |
| 2166543 | Reduction methods for the modeling and the simulation of combustion processes (p. 337)            | S    | V. Bykov, U. Maas                |
| 2115996 | Rail Vehicle Technology (p. 340)  | W/S  | P. Gratzfeld                     |
| 2173585 | Fatigue of Metallic Materials (p. 341)  | W    | K. Lang                          |
| 2117061 | Safety Engineering (p. 343)   | W    | H. Kany                          |
| 2114095 | Simulation of Coupled Systems (p. 345)  | S    | M. Geimer                        |
| 2149605 | Simulation of production systems and processes (p. 346)   | W    | K. Furmans, V. Schulze, P. Stock |
| 2154044 | Scaling in fluid dynamics (p. 348)  | S    | L. Bühler                        |
| 2163113 | Theory of Stability (p. 349)  | W    | A. Fidlin                        |
| 2150683 | Control Technology (p. 350)   | S    | C. Gönnheimer                    |
| 2146193 | Strategic Product Planning (p. 352)   | S    | A. Siebe                         |
| 2153406 | Flows with chemical reactions (p. 354)  | W    | A. Class                         |
| 2189910 | Flows and Heat Transfer in Energy Technology (p. 355)   | W    | X. Cheng                         |
| 2125763 | Structural and phase analysis (p. 356)  | W    | S. Wagner                        |
| 2126775 | Structural Ceramics (p. 357)  | S    | M. Hoffmann                      |
| 2177618 | Superhard Thin Film Materials (p. 359)  | W    | S. Ulrich                        |
| 2117062 | Supply chain management (p. 360)  | W    | K. Alicke                        |
| 2146192 | Sustainable Product Engineering (p. 361)  | S    | K. Ziegahn                       |
| 2161117 | Theoretical Description of Mechatronic Systems (p. 365)   | W    | W. Seemann                       |
| 2158107 | Technical Acoustics (p. 366)  | S    | M. Gabi                          |
| 2106002 | Computer Engineering (p. 367)   | S    | G. Bretthauer                    |
| 2121001 | Integrated Information Systems for engineers (p. 368)   | S    | J. Ovtcharova                    |
| 2146179 | Technical Design in Product Development (p. 371)  | S    | M. Schmid                        |
| 2174579 | Technology of steel components (p. 372)   | S    | V. Schulze                       |
| 2189904 | Ten lectures on turbulence (p. 373)   | W    | I. Otic                          |
| 2157445 | Computational methods for the heat protection of a full vehicle (p. 375)                          | W    | H. Reister                       |
| 2169453 | Thermal Turbomachines I (p. 378)  | W    | H. Bauer                         |
| 2170476 | Thermal Turbomachines II (p. 379)   | S    | H. Bauer                         |
| 2194650 | Materials under high thermal or neutron loads (p. 374)  | S    | A. Möslang, M. Rieth             |
| 2169472 | Thermal Solar Energy (p. 376)   | W    | R. Stieglitz                     |
| 2193002 | Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises) (p. 380)   | W    | H. Seifert, D. Cupid             |
| 2113080 | Tractors (p. 381)   | W    | M. Kremmer                       |

| ID      | Course  | Term | Lecturer                          |
|---------|---|------|-----------------------------------|
| 2181114 | Tribology (p. 382)  | W    | M. Scherge, M. Dienwiebel         |
| 2169462 | Turbine and compressor Design (p. 383)  | W    | H. Bauer, A. Schulz               |
| 2170478 | Turbo Jet Engines (p. 384)  | S    | H. Bauer, A. Schulz               |
| 2150681 | Metal Forming (p. 386)  | S    | T. Herlan                         |
| 2190499 | Vacuum and Tritium Technology (p. 388)  | S    | C. Day, B. Bornschein, D. Demange |
| 2167048 | Combustion diagnostics (p. 389)   | W/S  | R. Schießl, U. Maas               |
| 2138336 | Behaviour Generation for Vehicles (p. 390)  | S    | C. Stiller, T. Dang               |
| 2181715 | Failure of Structural Materials: Fatigue and Creep (p. 391)                                       | W    | O. Kraft, P. Gumbsch, P. Gruber   |
| 2181711 | Failure of structural materials: deformation and fracture (p. 392)                                | W    | P. Gumbsch, O. Kraft, D. Weygand  |
| 2149655 | Gear Cutting Technology (p. 394)  | W    | M. Klaiber                        |
| 3122031 | Virtual Engineering (Specific Topics) (p. 396)  | S    | J. Ovtcharova                     |
| 2121352 | Virtual Engineering I (p. 397)  | W    | J. Ovtcharova                     |
| 2122378 | Virtual Engineering II (p. 398)   | S    | J. Ovtcharova                     |
| 2166534 | Heatpumps (p. 400)  | S    | H. Wirbser, U. Maas               |
| 2170495 | Hydrogen Technologies (p. 403)  | S    | T. Jordan                         |
| 2161219 | Wave Propagation (p. 404)   | W    | W. Seemann                        |
| 2174586 | Material Analysis (p. 405)  | S    | J. Gibmeier                       |
| 2174574 | Materials for Lightweight Construction (p. 406)   | S    | K. Weidenmann                     |
| 2182740 | Materials modelling: dislocation based plasticity (p. 407)  | S    | D. Weygand                        |
| 2181738 | Scientific computing for Engineers (p. 409)   | W    | D. Weygand, P. Gumbsch            |
| 2169470 | Two-Phase Flow and Heat Transfer (p. 410)   | W    | T. Schulenberg, M. Wörner         |
| 2141853 | Polymers in MEMS A: Chemistry, Synthesis and Applications (p. 300)                                | W    | B. Rapp                           |
| 2141854 | Polymers in MEMS B: Physics, Microstructuring and Applications (p. 302)                           | W    | M. Worgull                        |
| 2115916 | Innovation Workshop: Mobility concepts for the year 2050 (p. 198)                                 | W/S  | P. Gratzfeld                      |
| 2189907 | Heat Transfer in Nuclear Reactors (p. 401)  | S    | X. Cheng                          |
| 2189903 | Introduction to Nuclear Energy (p. 114)   | W    | X. Cheng                          |
| 2154407 | Flows in rotating systems (p. 353)  | S    | R. Bohning                        |
| 2153405 | Finite Difference Methods for numerical solution of thermal and fluid dynamical problems (p. 107) | W    | C. Günther                        |
| 2154200 | (p. 161)  | S    | F. Magagnato                      |
| 2113809 | Automotive Engineering I (p. 91)  | W    | F. Gauterin, M. Gießler           |
| 2158206 | (p. 268)  | S    | F. Schmidt                        |
| 2130974 | Introduction to Nuclear Engineering (p. 115)  | S    | X. Cheng                          |

### Learning Control / Examinations

graded oral exam

### Conditions

None.

### Learning Outcomes

This elective course serves as in-depth, interdisciplinary analysis of a topic in mechanical engineering selected by the student.

### Content

see chosen elective subject

### 3.3 Modellbildung und Simulation

#### Module: Modeling and Simulation [MSc-Modul 05, MS]

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

| ECTS Credits | Cycle | Duration |
|--------------|-------|----------|
| 7            |       |          |

#### Courses in module

| ID      | Course                            | Hours per week<br>C/E/T | Term | CP | Responsible<br>Lecturer(s)                 |
|---------|-----------------------------------|-------------------------|------|----|--|
| 2185227 | Modelling and Simulation (p. 265) | 4                       | W    | 7  | C. Proppe, K. Furmans, B. Pritz, M. Geimer |

#### Learning Control / Examinations

written, auxiliary means: own manuscripts

#### Conditions

none

#### Recommendations

none

#### Learning Outcomes

Students are able to explain models and simulations as part of many disciplines of mechanical engineering. They are able to reproduce the interdisciplinary aspects of typical modeling and simulation techniques in mechanical engineering. The students are proficient in simulation studies from problem formulation to modeling, simulation, verification and validation, ie:

- They are able to formulate the steps necessary to resolve problems arising in engineering, to create appropriate conceptual and mathematical models and to analyze them.
- They are able to develop and implement algorithms for the solution of mathematical models.
- They are able to perform comprehensive and interdisciplinary simulation studies to assess the simulation results and to critically evaluate the quality of the simulation results.

#### Content

Introduction: Overview, concept formation, simulation studies, time/event-discrete models, event-oriented/process orientated/transaction-oriented view, typical model classes (operation/maintenance, storekeeping, loss-susceptible systems)

Time-continuous models with concentrated parameters, model characteristics and model analysis, numerical treatment of ordinary differential equations and differential-algebraic sets of equations, coupled simulation of time-continuous models with concentrated parameters

Time-continuous models with distributed parameters, description of systems by means of partial differential equations, model reduction, numerical solution procedures for partial differential equations

### 3.4 Produktentstehung

#### Module: Product Development [MSc-Modul 06, PE]

**Coordination:** S. Matthiesen, A. Albers  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

| ECTS Credits | Cycle                       | Duration |
|--------------|-----------------------------|----------|
| 15           | Every 2nd term, Summer Term | 1        |

#### Courses in module

| ID      | Course   | Hours per week<br>C/E/T | Term | CP | Responsible<br>Lecturer(s)                     |
|---------|--|-------------------------|------|----|--|
| 2146176 | Product Development - Methods of Product Development (p. 310)        | 3                       | S    | 6  | A. Albers, N. Burkardt, Dipl.-Ing. N. Burkardt |
| 2150510 | Product Development - Manufacturing and Material Technology (p. 311) | 6                       | S    | 9  | V. Schulze, F. Zanger                          |

#### Learning Control / Examinations

Two exams, according to the lectures.

#### Conditions

none

#### Learning Outcomes

The students are ...

- able to name, compare and use the central methods and process models of product development within moderate complex technical systems.
- able to explain problem solving techniques and associated development methods.
- able to explain product profiles and to differentiate and choose suitable creative techniques of solution finding on this basis.
- capable of finding appropriate materials for application under consideration of technical and economical frame conditions using the basics of materials selection.
- enabled to identify correlations between different manufacturing processes and are qualified to evaluate them regarding specific applications based on technical and economic aspects as well as to make a material and process selection with the CES Edupack.
- able to generate new solutions in the field of product development under consideration of scientific theories, principles and methods.

#### Content

life cycle of technical systems  
 integration of product development, production technology and material sciences  
 teaching of corresponding activities and supporting methods

### 3.5 Fachpraktikum

#### Module: Specialized Practical Training [MSc-Modul 07, FP]

**Coordination:** C. Stiller, K. Furmans  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

| ECTS Credits | Cycle | Duration |
|--------------|-------|----------|
| 3            |       |          |

| ID      | Course   | Term | Lecturer   |
|---------|--|------|--|
| 2117084 | Decentrally controlled intralogistic systems (p. 105)              | W    | K. Furmans, T. Baur  |
| 2175590 | Metallographic Lab Class (p. 139)                                  | W/S  | K. von Klinski-Wetzel  |
| 2115808 | Motor Vehicle Laboratory (p. 212)                                  | W/S  | M. Frey, M. Bürckert   |
| 2171487 | Laboratory Exercise in Energy Technology (p. 219)                  | W/S  | H. Bauer, U. Maas, H. Wirbser  |
| 2105014 | Laboratory mechatronics (p. 251)                                   | W    | A. Albers, G. Bretthauer, C. Proppe, C. Stiller  |
| 2138328 | Measurement Instrumentation Lab (p. 253)                           | S    | C. Stiller, P. Lenz  |
| 2143875 | Introduction to Microsystem Technology - Practical Course (p. 306) | W/S  | A. Last  |
| 2183640 | Laboratory "Laser Materials Processing" (p. 305)                   | W/S  | J. Schneider, W. Pfleging  |
| 2110678 | Production Techniques Laboratory (p. 317)                          | S    | K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL |
| 2161241 | Schwingungstechnisches Praktikum (p. 342)                          | S    | H. Hetzler, A. Fidlin  |
| 2134001 | Engine Laboratory (p. 271)   | S    | U. Wagner  |

#### Learning Control / Examinations

is according to the chosen course

#### Conditions

none

#### Recommendations

none

#### Learning Outcomes

Students are able to:

- Model typical problems in the laboratory and use typical methods of mechanical science to inquire,
- Built experiment designs, while choosing appropriate system components and models,
- Accomplish experiments goal-oriented,
- Analyse and evaluate results of experiments.

#### Content

see chosen practical training

#### Remarks

One of the training courses has to be chosen.

### 3.6 Mathematische Methoden im Masterstudiengang

#### Module: Mathematic Methods [MSc-Modul 08, MM]

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

|                     |              |                 |
|---------------------|--------------|-----------------|
| <b>ECTS Credits</b> | <b>Cycle</b> | <b>Duration</b> |
| 6                   |              |                 |

| ID      | Course  | Term | Lecturer                 |
|---------|---|------|--------------------------|
| 2161206 | Mathematical Methods in Dynamics (p. 235)                       | W    | C. Proppe                |
| 2161254 | Mathematical Methods in Strength of Materials (p. 236)          | W    | T. Böhlke                |
| 2162241 | Mathematical methods of vibration theory (p. 238)               | S    | W. Seemann               |
| 2154432 | Mathematical Methods in Fluid Mechanics (p. 239)                | S    | A. Class, B. Frohnappel  |
| 2162280 | Mathematical Methods in Structural Mechanics (p. 240)           | S    | T. Böhlke                |
| 01874   | Numerical Mathematics (p. 281)                                  | S    | C. Wieners, Neuß, Rieder |
| 0186000 | Probability Theory and Statistics (p. 402)                      | W/S  | D. Hug                   |
| 2117059 | Mathematical models and methods for Production Systems (p. 243) | W    | K. Furmans, J. Stoll     |

#### Learning Control / Examinations

graded oral examination

#### Conditions

None.

#### Learning Outcomes

Students will deepen and explain mathematical methods and transfer them to a variety of engineering problems. They are able to select suitable methods and transfer them to new problems.

The specific learning outcomes are defined by the respective coordinator of the course.

#### Content

see chosen elective subject

### 3.7 Schwerpunkt

#### Module: Major Field 1 [MSc-Modul 09, SP 1]

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

| ECTS Credits | Cycle | Duration |
|--------------|-------|----------|
| 16           |       |          |

#### Learning Control / Examinations

oral exam

#### Conditions

see Studienplan

#### Learning Outcomes

As part of a major field a domain of mechanical engineering is made accessible in breadth and depth. Students gain comprehensive knowledge in the core subjects and detailed knowledge in the supplementary subjects of the selected domain, where they are able to successfully carry out complex projects as well as to develop and implement innovations.

The specific learning outcomes are defined by the respective coordinator of the major field.

#### Content

see chosen major field

#### Remarks

In total, three major fields have to be chosen, one in the bachelor's program and two in the master's program (see Studienplan).

**Module: Major Field 2 [MSc-Modul 10, SP 2]**

**Coordination:** C. Proppe  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

| ECTS Credits | Cycle | Duration |
|--------------|-------|----------|
| 16           |       |          |

**Learning Control / Examinations**

oral exam

**Conditions**

see Studienplan

**Learning Outcomes**

As part of a major field a domain of mechanical engineering is made accessible in breadth and depth. Students gain comprehensive knowledge in the core subjects and detailed knowledge in the supplementary subjects of the selected domain, where they are able to successfully carry out complex projects as well as to develop and implement innovations.

The specific learning outcomes are defined by the respective coordinator of the major field.

**Content**

see chosen major field

**Remarks**

In total, three major fields have to be chosen, one in the bachelor's program and two in the master's program (see Studienplan).

### 3.8 Wahlfach Nat/inf/etit

#### Module: Elective Subject Natural Science/Computer Science/Electrical Engineering [MSc-Modul 11, WF NIE]

**Coordination:** U. Maas  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

| ECTS Credits | Cycle | Duration |
|--------------|-------|----------|
| 6            |       |          |

| ID      | Course                                       | Term | Lecturer                      |
|---------|--|------|-------------------------------|
| 23620   | Hardware/Software Codesign (p. 187)          | W    | M. Hübner                     |
| 2153429 | Magnetohydrodynamics (p. 225)                | W    | L. Bühler                     |
| 2143876 | Nanotechnology with Clusterbeams (p. 274)    | W/S  | J. Gspann                     |
| 23737   | Photovoltaics (p. 291)                       | S    | M. Powalla                    |
| 2181612 | Physical basics of laser technology (p. 293) | W    | J. Schneider                  |
| 22949   | Rheometry and Rheology (p. 339)              | W    | N. Willenbacher, B. Hochstein |
| 2153406 | Flows with chemical reactions (p. 354)       | W    | A. Class                      |
| 23605   | Systems and Software Engineering (p. 363)    | W    | K. Müller-Glaser              |
| 2106002 | Computer Engineering (p. 367)                | S    | G. Bretthauer                 |
| 23113   | Methods of Signal Processing (p. 255)        | W    | Puente León                   |
| 23109   | (p. 344)                                     | W    | F. Puente, F. Puente León     |

#### Learning Control / Examinations

Please refer to the description of the different courses.

#### Conditions

None.

#### Recommendations

None.

#### Learning Outcomes

After completing the elective course the attendents can explain the fundamentals in a specific subject of science, computer science or electrical engineering.

Detailed learning targets are described in the individual courses.

#### Content

Please refer to the description of the listed courses.

### 3.9 Wahlfach Wirtschaft/Recht

#### Module: Elective Subject Economics/Law [MSc-Modul 12, WF WR]

**Coordination:** K. Furmans  
**Degree programme:** MSc Maschinenbau (M.Sc.)  
**Subject:**

| ECTS Credits | Cycle | Duration |
|--------------|-------|----------|
| 4            |       |          |

| ID      | Course  | Term | Lecturer   |
|---------|---|------|------------|
| 2109036 | Human Factors Engineering II (p. 77)                      | W    | B. Deml    |
| 2581963 | The Management of R&D Projects with Case Studies (p. 140) | W/S  | H. Schmied |
| 2145184 | Leadership and Product Development (p. 218)               | W    | A. Ploch   |
| 2110017 | Leadership and Conflict Management (in German) (p. 226)   | S    | H. Hatzl   |
| 24016   | Public Law I - Basic Principles (p. 287)                  | W    | G. Sydow   |
| 24656   | Patent Law (p. 290)                                       | S    | P. Bittner |
| 2149667 | Quality Management (p. 328)                               | W    | G. Lanza   |

#### Learning Control / Examinations

A performance assessment is obligatory and can be oral, a written exam, or of another kind (depends on the selected course). A statement of attendancy is not sufficient.

#### Conditions

none

#### Recommendations

none

#### Learning Outcomes

Students can enlarge their knowledge about law and economics which affect mechanical engineering self-determined. They are able to describe circumstances of the case considering law or economics and apply it to simple cases. Later on in work life, they are able to evaluate, if and which subject specific support is necessary.

#### Content

see chosen subject

#### Remarks

Recommended courses are for instance related to innovation management and interlectual property.

### 3.10 Veranstaltungen in englischer Sprache

#### Module: Lectures in English (M.Sc.) [Englischsprachige Veranstaltungen (M.Sc.)]

**Coordination:**

**Degree programme:** MSc Maschinenbau (M.Sc.)

**Subject:**

**ECTS Credits**   **Cycle**   **Duration**

#### Courses in module

| ID            | Course  | Hours per week<br>C/E/T | Term | CP  | Responsible<br>Lecturer(s) |
|---------------|---|-------------------------|------|-----|----------------------------|
| 2189904       | Ten lectures on turbulence (p. 373)   | 2                       | W    | 4   | I. Otic                    |
| 2190490       | Introduction to Neutron Cross Section Theory and Nuclear Data Generation (p. 200)                 | 2                       | S    | 4   | R. Dagan                   |
| 2189920       | Nuclear Fusion Technology (p. 279)  | 2                       | W    | 4   | A. Badea                   |
| 2130910       | CFD for Power Engineering (p. 100)  | 2                       | S    | 4   | I. Otic                    |
| 2142884       | Microoptics and Lithography (p. 258)  | 2                       | S    | 4   | T. Mappes                  |
| 2161224       | Machine Dynamics (p. 228)   | 3                       | S    | 5   | C. Proppe                  |
| 2169453       | Thermal Turbomachines I (p. 378)  | 3                       | W    | 6   | H. Bauer                   |
| 2170476       | Thermal Turbomachines II (p. 379)   | 3                       | S    | 6   | H. Bauer                   |
| 2581998       | Basics of Liberalised Energy Markets (p. 93)  | 2/1                     | W    | 3,5 | W. Fichtner                |
| 2199115       | Chemical Fuels (p. 101)   | 2                       | S    | 4   | G. Schaub                  |
| 2199102       | Power Electronics (p. 304)  | 2                       | S    | 3   | A. Kloenne                 |
| 2300002       | Electric Power Generation and Power Grid (p. 124)   | 2                       | W    | 3   | B. Hoferer                 |
| 23315         | Electrical Machines (p. 125)  | 2                       | S    | 4   | M. Doppelbauer             |
| 2190465       | Fundamentals of reactor safety for the operation and dismantling of nuclear power plants (p. 179) | 2                       | W    | 4   | V. Sánchez-Espinoza        |
| 23682         | Superconducting Materials for Energy Applications (p. 358)  | 2                       | S    | 3   | M. Noe, F. Grilli          |
| 2169461       | Coal fired power plants (p. 207)  | 2                       | W    | 4   | P. Fritz, T. Schulenberg   |
| 2170490       | Combined Cycle Power Plants (p. 160)  | 2                       | S    | 4   | T. Schulenberg             |
| 2157451       | Wind and Hydropower (p. 408)  | 2                       | W    | 4   | M. Gabi, N. Lewald         |
| 2189921       | Nuclear Power and Reactor Technology (p. 280)   | 3                       | W    | 6   | A. Badea                   |
| 2199119       | Modern Software Tools in Power Engineering (p. 269)   | 3                       | S    | 6   | T. Leibfried               |
| 2199120       | Electrical Power Transmission and Grid Control (p. 127)   | 3                       | W    | 6   | T. Leibfried               |
| 2146440       | Range Extender (p. 330)   | 2                       | W    | 6   | H. Bauer                   |
| 22528         | Applied Combustion Technology (p. 74)   | 2                       | S    | 4   | N. Zarzalis                |
| 22531         | Laboratory Work in Combustion Technology (p. 214)   | 2                       | S    | 4   | N. Zarzalis                |
| 0109400       | Mathematical Modelling and Simulation (p. 233)  | 2                       | W    | 4   | G. Thäter, V. Heuveline    |
| 23486 / 23487 | Optoelectronic Components (p. 288)  | 2 / 1                   | S    | 4,5 | W. Freude                  |

|         |   |     |     |     |                        |
|---------|---|-----|-----|-----|------------------------|
| 2581012 | Renewable Energy – Resources, Technology and Economics (p. 338) | 2/0 | W   | 3,5 | R. McKenna             |
| 2189907 | Heat Transfer in Nuclear Reactors (p. 401)                      | 2   | S   | 4   | X. Cheng               |
| 2189901 | Tutorial for Heat Transfer in Nuclear Reactors (p. 385)         | 1   | W/S | 1   | X. Cheng               |
| 2145186 | Mechanical Design I (p. 245)                                    | 4   | W   | 4   | A. Albers, N. Burkardt |

### Learning Control / Examinations

#### Conditions

None.

#### Learning Outcomes

#### Content

## 4 Courses

### 4.1 All Courses

#### Course: Analysis of Exhaust Gas und Lubricating Oil in Combustion Engines [2134150]

**Coordinators:** M. Gohl

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

#### Learning Control / Examinations

Letter of attendance or oral exam (25 minutes, no auxillary means)

#### Conditions

none

#### Recommendations

Knowledge in the field of engine technology and measurement techniques is advantageous

#### Learning Outcomes

The Students can point out the challenges concerning the current emission standards in engine development. They can name and explain the basic principles of measurement techniques and methods to analyse exhaust gas components and components of engine oil. Hence, the students have the ability to choose the right methods for a given Problem and to interpret the results.

#### Content

The students get involved in the application of different measurement techniques in the field of exhaust gas and lubricating oil analysis. The functional principles of the systems as well as the application areas of the latter are discussed. In addition to a general overview of standard applications, current specific development and research activities are introduced.

#### Media

Lecture with Powerpoint slides

#### Literature

The lecture documents are distributed during the courses.

## Course: Adaptive Control Systems [2105012]

**Coordinators:** G. Bretthauer

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral examination (1 hour)

Duration: 1 hours, also possible as an optional or part of a major subject

Auxiliary means: none

### Conditions

Measuring and Automatic Control

### Learning Outcomes

The students know different types, structures and operation of adaptive control systems. They are capable of setting up system equations theoretically and experimentally. By experimenting with examples students are prepared to apply adaptive control systems in practice.

### Content

Introduction: definitions, classification of adaptive control systems, objectives

Structures of adaptive control systems: overview, parameter-, structure- and signal-adaptive control systems, open-loop and closed loop ARS, ARS with reference/identification model, application

Modeling: methods, experimental conditions, experimental modeling, identification methods for single input single output systems and multi input multi output systems

Parameter adaptive control systems: definitions, design methods

### Literature

W. Weber. Adaptive Regelungssysteme, volume I, II. R. Oldenbourg, München, 1971.

**Course: Aerodynamics [2154420]****Coordinators:** F. Ohle**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral, 30 min,  
 auxiliary means: none

**Conditions**

none

**Recommendations**

Grundlagen der Strömungsmechanik, Mathematische Methoden der Strömungsmechanik

**Learning Outcomes**

The students can explain the fundamentals of aerodynamics as relevant for aeronautics and aviation. They can describe varying flight conditions phenomenologically and mathematically and are furthermore qualified to comparatively analyze varying design concepts.

**Content**

- Basics of aerodynamics
- Basic properties of flowing gas
- Potential Theory
- Airfoils (2-D wing)
- The finite (3-D) wing
- Airplane performance
- CFD
- Experimental verification

**Literature**

J.D. Anderson, jr.. Fundamentals of Aerodynamics, McGraw-Hill

E.L. Houghton. Aerodynamics for Engineering Students, Butterworth-Heinemann (Elsevier)

Schlichting, Gersten. Grenzschichttheorie, Springer

**Remarks**

Block course with limited number of participants, registration in the secretary's office required.

See details at [www.istm.kit.edu](http://www.istm.kit.edu).

**Course: Aerothermodynamics [2154436]****Coordinators:** F. Seiler**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

no auxiliary means

**Conditions**

none

**Learning Outcomes**

The students can describe the aerodynamic problems occurring during re-entry of space vehicles into the earth's atmosphere. They are able to explain the interrelation of high Mach number flow regimes and the co-occurring real gas effects (physics and chemistry of hot gases). Furthermore, they can discuss the link between the thermodynamics of hot air and the flow development at hypersonic flow conditions coupled with extreme heat flux phenomena in the frame of the term "Aerothermodynamics". Beyond the basic knowledge gained in the lecture on "Fluid Mechanics" the students are qualified to discuss all fundamentals as necessary to cover the fluid mechanics of re-entry flight trajectory of a space vehicle. They are able to distinguish the applicability of gaskinetic methods and continuum theory with respect to atmospheric altitude. The students are able to apply scaling laws as needed to transfer hypersonic flow to ground facilities (shock tunnels). They are qualified to explain the working principle of such tunnels and can explain the required measuring techniques based on recently achieved results.

**Content**

- Nature of a hypersonic flow
- Fundamentals of aerothermodynamics
- Problems during re-entry
- Flow regimes during re-entry
- Applied hypersonic research

**Literature**

H. Oertel jun.: Aerothermodynamik, Springer-Verlag, Berlin Heidelberg New York, 1994

F. Seiler: Skript zur Vorlesung über Aerothermodynamik

**Remarks**

Block course with limited number of participants, registration in the secretary's office required. See details at [www.istm.kit.edu](http://www.istm.kit.edu)

## Course: Applied Tribology in Industrial Product Development [2145181]

**Coordinators:** A. Albers, W. Burger

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term |                      |

### Learning Control / Examinations

oral exam

### Conditions

none

### Learning Outcomes

The goal of the lecture is to discuss tribological problems, tribological features and the tribological variety on examples of the automobile industry.

The students are able to ...

- define a tribological system.
- design a tribological system.
- discuss wear and damage impacts.
- explain measurement techniques to investigate tribological systems.
- show the limits of a tribological system.

### Content

Friction, Wear, Wear Measurement

Lubricant (Oil, Grease, etc.)

Hydrodynamic and elastohydrodynamic Lubrication

Design of Tribologic Working Surface Pairs

Technique of Measurement in Lubricated Contacts

Prevention of Maschine Failure

Protective Surface Layers

Journal Bearings, Roller Bearings

Gear Wheels and Transmissions

### Literature

The lecture script will be allocated at Ilias.

**Course: Applied Materials Modelling [2181614]****Coordinators:** P. Gumbsch, B. Nestler, A. August**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 7            | 4              | Summer term | de                   |

**Learning Control / Examinations**

oral exam 35 minutes

no tools or reference materials

**Conditions**

compulsory preconditions: none

**Recommendations**

preliminary knowlegde in mathematics, physics and materials science

**Learning Outcomes**

The student can

- describe the physical foundation of particle based simulation methods and apply them to solve problems in materials science
- apply the method of phase-field modeling to simulate the microstructure formation during solidification
- use thermodynamic data bases and can couple appropriate energy functions with the microstructure simulations
- explain the influence of fluid flow on microstructure formation during solidification by using computational methods

**Content**

The lecture introduces the foundation of particle based simulation methods focussing on molecular dynamics.

In the part on mesoscopic methods, we introduce a fundamental phase-field model for the description of phase transition problems in two-phase material systems. The derivation of the dynamic evolution equation is based on an energy density functional. The various contributions of the governing equation are discussed. As an extension of the model, we couple a description of mass diffusion and treat different types of microstructure evolution in binary alloy systems such as dendrites, eutectics and peritectics. Since fluid flow has an important influence on the morphology of the solidifying structure, we elaborate a combined phase-field and fluid flow model and apply it to selected systems.

**Media**

black board, beamer, script, computer exercise

**Literature**

1. D. Frenkel, B. Smit: Understanding Molecular Simulation: From Algorithms to Applications, Academic Press, 2001
2. W. Kurz, D.J. Fisher: Fundamentals of Solidification, Trans Tech Publications, 1998
3. P. Haupt: Continuum Mechanics and Theory of Materials, Springer, 1999
4. M. P. Allen, D. J. Tildesley: Computer simulation of liquids, Clarendon Press, 1996

**Remarks**

From 2015 on the lecture/lab will be offered during summer term!

In winter term the lecture/lab will be offered for the last time during winter term 2014/2015!

## Course: Drive Train of Mobile Machines [2113077]

**Coordinators:** M. Geimer, M. Scherer

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

### Learning Control / Examinations

oral examination

### Conditions

None.

### Recommendations

- general basics of mechanical engineering
- basic knowledge in hydraulics
- interest in mobile machines

### Learning Outcomes

Get to know all relevant aspects and components of a drive train of a mobile machine and also the construction of various drive trains. Knowing and understanding interactions and independancies of components on a basic level.

### Content

In this course will be discussed the different drive train of mobile machinerys. The fokus of this course is:

- improve knowledge of fundamentals
- mechanical gears
- torque converter
- hydrostatic drives
- continuous variable transmission
- electrical drives
- hybrid drives
- axles
- terra mechanic

### Media

projector presentation

### Literature

download of scriptum via ILIAS

## Course: Application of technical logistics in modern crane systems [2117064]

**Coordinators:** M. Golder

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral, approx. 20min, appointment after acknowledgement

### Conditions

none

### Recommendations

technical interest; Beneficial: Knowledge of the lecture 'Technical logistics I, basics'

### Learning Outcomes

Students are able to:

- Dimension modern crane installations and transfer this approach to other material handling installations and
- Judge about the confirmity of the system by using relevant standards and set of rules.

### Content

- Basics of modern crane construction
- Characteristics of application, classification
- Configuration, dimensioning, consideration of costs
- Relevant rules and standards
- Modern concepts of crane control and drives

### Media

presentations, black board

### Literature

None.

### Remarks

none

## Course: Application of technical logistics in sorting- and distribution technology [2118089]

**Coordinators:** J. Föllner

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral 30 min

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

Students are able to:

- Describe and classify basics and characteristics of application of sorting and distribution of goods,
- Solve drive and control tasks with appropriate concept selection,
- Design systems with appropriate calculation methods and evaluate them financially, and
- Judge about the confirmity of the system by using relevant standards and set of rules.

### Content

Basics of goods sorting and distribution technology, employment characteristics, classification, interpretation, dimensioning, costs considerations. Relevant control, modern sets of rules and propulsion principles

### Media

presentations, black board

### Literature

None.

### Remarks

none

## Course: Application of advanced programming languages in mechanical engineering [2182735]

**Coordinators:** D. Weygand

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

None.

### Learning Outcomes

The student can

- utilise the programming language Fortran 95 and Fortran 2003 to implement simple numerical simulations
- apply a script languages awk resp. python for data treatment

### Content

This lecture gives an introduction to advances programming and scripting languages and numerical methods under UNIX/Linux:

- \* Fortran 95/2003
  - structure of source code
  - programming
  - compiling
  - debugging
  - parallelization with OpenMP
- \* numerical methods
- \* script languages: Python, awk
- \* visualisation

### Literature

1. fortran 95/2003 explained, M. Metcalf, J. Reid, M. Cohen, Oxford University Press 2004.
2. Intel Fortran compiler handbook.

## Course: Applied Combustion Technology [22528]

**Coordinators:** N. Zarzalis

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

The examination results from the chosen module.

### Conditions

fluid mechanics, heat and mass transfer

### Learning Outcomes

Students learn to design burners for gaseous and liquid fuels. Furthermore, they know about the design parameters which influence the flame geometry and they can apply this knowledge in order to engineer the flame shape.

### Content

- Combustion and Thermo Chemistry
- Fuels
- Laminar flames
- Turbulent flames
- Flame stabilisation
- Burner design and scaling
- Droplet evaporation and combustion
- Combustion of solid fuels

## Course: Human Factors Engineering I [2109035]

**Coordinators:** B. Deml

**Part of the modules:** Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Compulsory Core Subject:** oral exam

**Elective Subject:** oral exam (ca. 30 min)

**Compulsory Optional Subject:** written exam (60 min)

**Optional Subject:** oral exam (ca. 30 min)

The exams are only offered in German!

### Conditions

- The exams “Arbeitswissenschaft I (2109035)” and “Ergonomie und Arbeitswirtschaft (2109029)” are mutually exclusive.
- The exams “Arbeitswissenschaft I (2109035)” and “Arbeitsschutz und Arbeitsrecht (2109024)” are mutually exclusive.
- The exams “Arbeitswissenschaft I (2109035)” and “Arbeitswissenschaft (2109026)” are mutually exclusive.

### Recommendations

- Willingness to learn interdisciplinarily (Product design, Legal regulations Work physiology, Work psychology ...)
- Basic knowledge of Production Management is useful

### Learning Outcomes

After completion the lecture, the students are able

- to classify basics of human work and to apply basic research methods of Human Factors Engineering,
- to evaluate and design work places following the goals of Human Factors Engineering under consideration of psychological, physiological, anthropometric, safety-related, organisational as well as technological aspects,
- evaluate and configure work environments following the goals of Human Factors Engineering under consideration of noise, illumination, climate and mechanical vibrations,
- to classify and apply basic theories and methods of Human Factors Engineering. They are able to evaluate a work place and to derive corresponding wage concepts,
- to rate problems of labor-law and to describe the organisation of the representation of interests in the German working world.

### Content

1. Introduction
2. Basics of human performance
3. Research methods of Human Factors Engineering

4. Design of workplaces
5. Design of working environment
6. Industrial Engineering
7. Labour legislation and Representation of interest groups

**Literature****Learning material:**

Handout and literature online ILIAS.

**Literature:**

- SCHLICK, Christopher; BRUDER, Ralph; LUCZAK, Holger: Arbeitswissenschaft. Heidelberg u.a.: Springer, 3rd edition 2010.

Please refer to the latest edition.

## Course: Human Factors Engineering II [2109036]

**Coordinators:** B. Deml

**Part of the modules:** Elective Subject Economics/Law (p. 61)[MSc-Modul 12, WF WR], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Compulsory Core Subject:** oral exam

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject Economics/Law:** written exam (60 min)

**Optional Subject:** oral exam (ca. 30 min)

The exams are only offered in German!

### Conditions

- The exams “Arbeitswissenschaft II (2109036)” and “Arbeitsschutz und Arbeitsrecht (2109024)” are mutually exclusive.
- The exams “Arbeitswissenschaft II (2109036)” and “Arbeitswissenschaft (2109026)” are mutually exclusive.

### Learning Outcomes

After completion the lecture, the students are able

- to classify basics of the research within work organisation and to apply basic research methods of Human Factors Engineering. They know actual trends of work organisation.
- to apply fundamental methods of employee selection, personnel development and employee appraisal. They know basic theories of work satisfaction and motivation.
- to consider important psychological aspects of teams (e.g. interaction, communication). They know fundamental theories about leadership.
- to apply and evaluate methods of human-resource allocation and the fundamental basics of departmental, process and production organisation.

### Content

1. Introduction
2. Basics of work organisation
3. Research methods of work organisation
4. Individual person
5. Group
6. Organisation

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- SCHLICK, Christopher; BRUDER, Ralph; LUCZAK, Holger: Arbeitswissenschaft. Heidelberg u.a.: Springer, 3rd edition 2010.

Please refer to the latest edition.

## Course: Atomistic simulations and molecular dynamics [2181740]

**Coordinators:** P. Gumbsch

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

compulsory preconditions: none

### Recommendations

preliminary knowlegde in mathematics, physics and materials science

### Learning Outcomes

The student can

- describe the physical foundation of particle based simulation method (e.g. molecular dynamics)
- apply particle based simulation methods to problems in materials science

### Content

The lecture introduces the foundation of particle based simulation methods focussing on molecular dynamics:

1. Introduction
2. Physics of Materials
3. MD Basics, Atom-Billard
  - \* particle, position, energy, forces, pair potentials
  - \* initial and boundary conditions
  - \* time integration
4. algorithms
5. static, dynamic, thermodynamic
6. MD output
7. interaction between particles
  - \* pair potential – many body potentials
  - \* principles of quantum mechanics
  - \* tight binding methods
  - \* dissipative particle dynamics
8. application of particle based methods

### Literature

1. Understanding Molecular Simulation: From Algorithms to Applications, Daan Frenkel and Berend Smit (Academic Press, 2001)
2. Computer simulation of liquids, M. P. Allen and Dominic J. Tildesley (Clarendon Press, Oxford, 1996)

**Course: Constitution and Properties of Wear resistant materials [2194643]****Coordinators:** S. Ulrich**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination (30 min)

no tools or reference materials

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

Basic understanding of constitution of wear-resistant materials, of the relations between constitution, properties and performance, of principles of increasing of hardness and toughness of materials as well as of the characteristics of the various groups of wear-resistant materials.

**Content**

introduction

materials and wear

unalloyed and alloyed tool steels

high speed steels

stellites and hard alloys

hard materials

hard metals

ceramic tool materials

superhard materials

new developments

**Literature**

Laska, R. Felsch, C.: Werkstoffkunde für Ingenieure, Vieweg Verlag, Braunschweig, 1981

Schedler, W.: Hartmetall für den Praktiker, VDI-Verlage, Düsseldorf, 1988

Schneider, J.: Schneidkeramik, Verlag moderne Industrie, Landsberg am Lech, 1995

Copies with figures and tables will be distributed

## Course: Constitution and Properties of Protective Coatings [2177601]

**Coordinators:** S. Ulrich

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral examination (30 min)

no tools or reference materials

### Conditions

None

### Recommendations

None

### Learning Outcomes

Transfer of the basic knowledge of surface engineering, of the relations between constitution, properties and performance, of the manifold methods of modification, coating and characterization of surfaces.

### Content

introduction and overview

concepts of surface modification

coating concepts

coating materials

methods of surface modification

coating methods

characterization methods

state of the art of industrial coating of tools and components

new developments of coating technology

### Literature

Bach, F.-W.: Modern Surface Technology, Wiley-VCH, Weinheim, 2006

Copies with figures and tables will be distributed

## Course: Selected Applications of Technical Logistics [2118087]

**Coordinators:** M. Mittwollen, Madzharov

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

### Learning Control / Examinations

after each lesson period; oral / written (if necessary) => (look at "Studienplan Maschinenbau", latest version)

### Conditions

look at Empfehlungen (en)

### Recommendations

GTL/ESTL should be visited in advance, knowledge out of GTL/ESTL preconditioned

### Learning Outcomes

Students are able to:

- Model the dynamic behaviour of material handling systems and based on this calculate the dynamical behaviour and
- Transfer this approach autonomous to further, different material handling installations and
- Discuss the knowledge with subject related persons.

### Content

design and dimension of machines from intralogistics // static and dynamic behaviour // operation properties and specifics // visit of real intralogistic system

Inside practical lectures: sample applications and calculations in addition to the lectures

### Media

supplementary sheets, projector, blackboard

### Literature

Recommendations during lessons

### Remarks

-

## Course: Selected Topics in Aeronautics and Astronautics I [2170454]

**Coordinators:** S. Wittig

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral

Duration: approximately 30 minutes

Supporting material: none

### Conditions

Basic principles of mathematics, thermodynamics, fluid mechanics, mechanics

### Learning Outcomes

The students are able to:

- analyse space systems
- comment on the integration of air traffic in the transport system due to the mobility requirements
- explain the physical-technical basics and judge the design and application of space vehicles and air transport concerning economic and ecological issues
- name the main components of various systems and application fields (e.g. earth observation, communication, space exploration, manned spaceflight) and explain their function
- define and analyse the requirements and design principles for aircrafts / aircraft fleets

### Content

Central topics are the analysis of space systems and of the air traffic with its impact on modern mobility requirements. The understanding of the fundamentals - physical and technological - is essential for the design and application of space vehicles as well as of an economically and ecologically efficient air transport. Based on recent developments the main components of the various systems and their design principles are introduced.

In the fall/winter semester an additional lecture course is offered.

#### I. Space Systems

Applications

Space Programms

Economical Aspects

Main Components

Influence Parameters

Space Missions

Launches

Satellites

#### II. Air Transport

Development: State of the art

Economical Aspects

Aircraft Design and Development

Aerodynamics

New Materials

Future Developments

### Literature

Messerschmidt, Ernst: Raumfahrt-systeme, Springer-Verlag 2005

Griffin, Michael D.: Space Vehicle Design; AIAA Education Series 2004

Hünecke, Klaus: Die Technik des modernen Verkehrsflugzeuges, Motorbuch-Verlag 2004

## Course: Selected Topics in Aeronautics and Astronautics II [2169486]

**Coordinators:** S. Wittig

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral

Duration: approximately 30 minutes

Supporting material: none

### Conditions

Basic Principles of Mathematics, Fluid Mechanics, Thermodynamics, Mechanics

### Learning Outcomes

The students possess the ability to:

- explain and evaluate the design principles of civil aircrafts
- analyse the requirements for civil aircrafts
- derive design and construction principles for aircraft fuselage and engines
- discuss (transient) loads during operation
- describe and apply the basic principles of orbital mechanic and maneuverability of satellites in space
- discuss launcher design and re-entry problems with ground and space segments

### Content

The main topics in the first half of the course is the civil aircraft design. Based on the analysis of the general requirements, design principles for aircraft fuselage and the engines are introduced. Various - including unsteady - loads during operation are discussed. The second part is directed towards the basic principles of orbital mechanic and maneuverability of satellites in space . Launcher design and re-entry problems with ground and space segments are introduced. In the spring/summer semester an additional lecture-course is offered.

#### I. Aircraft Design

Mission Envelope

Aircraft Engines

Design Concepts

Aerodynamic Loads

#### II. Space Systems and

Satellites

Orbital Mechanics

Orbital Transfer

Rocket Systems

Ground- and Space Segements

Re-entry

Future Missions

### Literature

Hünecke, Klaus: Die Technik des modernen Verkehrsflugzeuges, Motorbuch-Verlag, 2004

Hull, David, G.: Fundamentals of air-plane flight mechanics; Springer 2007

Messerschmid, Ernst: Raumfahrt-systeme, Springer-Verlag 2005

Griffin, Michael D.: Space Vehicle Design, AIAA Education Series 2004

**Course: Selected Topics on Optics and Microoptics for Mechanical Engineers [2143892]****Coordinators:** T. Mappes**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content**

**Course: Selected chapters of the combustion fundamentals [2167541]****Coordinators:** U. Maas**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The attendance of this course enables students to gain a deeper understanding of the mechanisms involved in the chemistry of combustion, droplet and spray combustion and the statistical modelling of turbulent combustion.

**Content**

Depending on the lecture: Fundamentals of chemical kinetics, of statistical modeling of turbulent flames or of droplet and spray combustion.

**Media**

Blackboard and Powerpoint presentation

**Literature**

Lecture notes on fundamentals of combustion (Prof. U. Maas)

Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation, authors: U. Maas, J. Warnatz, R.W. Dibble, Springer-Lehrbuch, Heidelberg 1996

## Course: Selected Problems of Applied Reactor Physics and Exercises [2190411]

**Coordinators:** R. Dagan

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral exam, 30 min.

### Conditions

none

### Recommendations

none

### Learning Outcomes

The students

- have solid understanding of the basic reactor physics
- are able to estimate processes of growth and decay of radionuclides; out of it, they can preform dose calculation and introduce their biological hazards
- can calculate the relationship of basic parameters which are needed for a stable reactor operation
- understand important dynamical processes of nuclear reactors.

### Content

- Nuclear energy and forces
- Radioactive decay
- Nuclear processes
- Fission and the importance of delayed neutrons
- Basics of nuclear cross sections
- Principles of chain reaction
- Static theory of mono energetic reactors
- Introduction to reactor kinetic
- student laboratory

### Literature

K. Wirtz Basics of Reactor technic Par I, II, Technic School Karlsruhe 1966 (in German)

D. Emendorfer. K.H. Höcker Theory of nuclear reactions, BI- Hochschultaschenbücher 1969 (in German)

J. Duderstadt and L. Hamilton, Nuclear reactor Analysis, J. Wiley \$ Sons, Inc. 1975.

## Course: Design of highly stresses components [2181745]

**Coordinators:** J. Aktaa

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral exam: 30 minutes

### Conditions

material science  
solid mechanics II

### Learning Outcomes

The students know about the rules of established design codes for the assessment of components which under operation are subjected to high thermo-mechanical and/or irradiation loadings. They understand which constitutive equations are used according to state-of-the-art of technology and research to estimate deformation and damage appearing under these loadings and to predict expected lifetime. They gained insight into the application of these generally non-linear constitutive equations in finite element codes and can judge the major issues which shall be thereby taken into account.

### Content

Contents of the lecture:

- rules of common design codes
- classical models for elasto-plasticity and creep
- lifetime rules for creep, fatigue and creep-fatigue interaction
- unified constitutive models for thermo-elasto-viscoplasticity
- continuum mechanical models for damage at high temperatures
- application of advanced material models in FE-codes

### Literature

- R. Viswanathan, Damage Mechanisms and Life Assessment of High-Temperature Components, ASM International, 1989.
- Lemaitre, J.; Chaboche J.L.: Mechanics of Solid Materials, Cambridge University Press, Cambridge, 1990.

## Course: Design and Development of Mobile Machines [2113079]

**Coordinators:** M. Geimer, J. Siebert

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

homework in small groups during the semester + oral examination

### Conditions

None.

### Recommendations

Knowledge in Fluid Technology (SoSe, LV 21093)

### Learning Outcomes

Students will learn:

1. How to develop a mobile working machine
2. How to apply existing knowledge on a specific problem
3. How to break down and structure a complex task
4. How knowledge of different courses can be brought together

### Content

Wheel loaders and excavators are highly specialized mobile machines. Their function is to detach, pick up and deposit materials near by. Significant size for dimensioning of the machines is the content of their standard shovel. In this lecture the main steps in dimensioning a wheel loader or excavator are being thought. This includes among others:

- 
- Defining the size and dimensions,
- the dimensioning of the drive train,
- Determining the kinematics of the equipment,
- the dimension of the working hydraulics and
- Calculations of strength

The entire design process of these machines is strongly influenced by the use of standards and guidelines (ISO/DIN-EN). Even this aspect is dealt with.

The lecture is based on the knowledge from the fields of mechanics, strength of materials, machine elements, propulsion and fluid technique. The lecture requires active participation and continued collaboration.

### Literature

None.

## Course: Dimensioning and Optimization of Power Train System [2146208]

**Coordinators:** E. Kirchner

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral Examination

### Conditions

none

### Learning Outcomes

The students gain the knowledge about ...

- functionality of conventional vehicle drive systems and design load for components.
- design- and functional principals of the main components of manual transmission, dual-clutch systems and automatic transmissions.
- comfort relevant interactions and corrective measures.
- requirements of hybridization and electrification of vehicles.
- evaluation on system level.

### Content

1. Architectures: conventional, hybrid and electrical transmissions
2. The gear as system in a vehicle
3. Components and power flow of synchromesh gears
4. Spur gears
5. Synchronization
6. Switching systems for vehicles with manual transmission
7. Actuators
8. Comfort aspects for manual transmissions
9. Torque converter
10. Planetary sets
11. Power conversion in automatic transmissions
12. Continuously variable transmission systems
13. Differentials and components for power split
14. Drive train for commercial vehicles
15. Gears and electrical machines for electro mobility

## Course: Automation Systems [2106005]

**Coordinators:** M. Kaufmann

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral, also possible as an optional or part of a major subject

### Conditions

None.

### Recommendations

Fundamentals of measuring and control engineering

### Learning Outcomes

Students have fundamental knowledge about functionality, composition, components and development of industrial automation systems.

### Content

- Introduction: Terms and definitions, examples, requirements
- Industrial processes: classification, process conditions
- Automation tasks
- Components of industrial automation systems: control functions, data acquisition, data output equipment, Programmable Logic Controllers, PC-based control
- Industrial communication, classification, topology, protocols, bus systems for automation systems
- Engineering: plant engineering, composition of control systems, programming
- Requirements on equipment, documentation, identification
- Dependability and safety
- Diagnosis
- Application examples

### Literature

- Gevatter, H.-J., Grünhaupt, U.: Handbuch der Mess- und Regelungstechnik in der Produktion. 2. Auflage, Berlin, Heidelberg: Springer-Verlag, 2006.
- Langmann, R.: Taschenbuch der Automatisierung. München: Fachbuchverlag Leipzig, 2010.
- Strohrmann, G.: Automatisierung verfahrenstechnischer Prozesse: eine Einführung für Ingenieure und Techniker. München, Wien: Oldenbourg-Industrieverlag, 2002.
- Wellenreuther, G., Zastrow, D.: Automatisieren mit SPS: Theorie und Praxis. 4. Auflage, Wiesbaden: Vieweg+Teubner, 2009.

**Course: Automotive Engineering I [2113809]****Coordinators:** F. Gauterin, M. Gießler**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term | en                   |

**Learning Control / Examinations**

Written examination

Duration: 120 minutes

Auxiliary means: none

**Conditions**

Examination in English

Can not be combined with lecture [2114835] Grundlagen der Fahrzeugtechnik I.

**Recommendations**

none

**Learning Outcomes**

The students know the movements and the forces at the vehicle and are familiar with active and passive security. They have proper knowledge about operation of engines and alternative drives, the necessary transmission between engine and drive wheels and the power distribution. They have an overview of the components necessary for the drive and have the basic knowledge, to analyze, to judge and to develop the complex system "vehicle".

**Content**

1. History and future of the automobile
2. Driving mechanics: driving resistances and driving performances, mechanics of the longitudinal and transverse forces, collision mechanics
3. Engines: combustion engine, alternative drives (e.g. electric motor, fuel cell)
4. Transmission: clutches (e.g. friction clutch, visco clutch), transmission (e.g. mechanical transmission, hydraulic fluid transmission)
5. Power transmission and distribution: drive shafts, cardon joints, differentials

**Literature**

1. Mitschke, M./ Wallentowitz, H.: Dynamik der Kraftfahrzeuge, Springer-Verlag, Berlin, 2004
2. Braes, H.-H.; Seiffert, U.: Handbuch Kraftfahrzeugtechnik, Vieweg&Sohn Verlag, 2005
3. Gnadler, R.: Script to the lecture 'Automotive Engineering I'

## Course: Rail System Technology [2115919]

**Coordinators:** P. Gratzfeld

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

### Learning Control / Examinations

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

### Conditions

none

### Recommendations

none

### Learning Outcomes

The students understand relations and interdependencies between rail vehicles, infrastructure and operation in a rail system.

They can assess the suitability of existing elements in the overall system.

They deduce the fundamental requirements for rail vehicles out of it.

### Content

Introduction: railway as system, history, networks, traffic development, economic impact

Vehicle dynamics: driving resistance, tractive effort diagram, load cycles

Wheel-rail-contact: carrying of vehicle mass, adhesion, wheel guidance

Train protection: succession of trains, guideway

Traction power supply: power networks, power distribution, substations

Vehicles: definitions, compositions

Environmental aspect: energy consumption, traffic area, noise

### Media

All slides are available for download (Ilias-platform).

### Literature

A bibliography is available for download (Ilias-platform).

### Remarks

none

## Course: Basics of Liberalised Energy Markets [2581998]

**Coordinators:** W. Fichtner

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3,5          | 2/1            | Winter term | en                   |

### Learning Control / Examinations

The assessment consists of a written exam according to Section 4(2), 1 of the examination regulation.

### Conditions

None.

### Learning Outcomes

The student has detailed knowledge concerning the new challenges of liberalised energy markets. He has the ability to:

- Understand the new economic reality of liberalised energy markets
- Obtain a deeper understanding of the different submarkets of the power market
- Identify problems of the liberalised energy markets

### Content

1. The European liberalisation process
  - 1.1 The concept of a competitive market
  - 1.2 The regulated market
  - 1.3 Deregulation in Europe
2. Pricing and investments in a liberalised power market
  - 2.1 Merit order
  - 2.2 Prices and investments
  - 2.3 Market flaws and market failure
  - 2.4 Regulation in liberalised markets
  - 2.5 Additional regulation mechanisms
3. The power market and the corresponding submarkets
  - 3.1 List of submarkets
  - 3.2 Types of submarkets
  - 3.3 Market rules
4. Risk management
  - 4.1 Uncertainties in a liberalised market
  - 4.2 Investment decisions under uncertainty
  - 4.3 Estimating future electricity prices
  - 4.4 Portfolio management
5. Market power
  - 5.1 Defining market power
  - 5.2 Indicators of market power
  - 5.3 Reducing market power
6. Market structures in the value chain of the power sector

### Media

Media will likely be provided on the e-learning platform ILIAS.

### Literature

#### Elective literature:

Power System Economics; Steven Stoft, IEEE Press/Wiley-Interscience Press, 0-471-15040-1

## Course: Fuels and Lubricants for Combustion Engines [2133108]

**Coordinators:** B. Kehrwald

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral examination, Duration: ca. 25 min., no auxiliary means

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

The students can name and explain composition and meaning of fuels, lubricants and coolants as important components in the system of today's Otto and Diesel engines as well as definition and chemical composition of fuels and lubricants, the meaning of crude oil as basic primary product, production processes, major properties, standards and specifications, testing methods.

They can point out future worldwide trends in the field of conventional and alternative fuels regarding emission standards and energy conservation

### Content

Introduction and basics

Fuels for Gasoline and Diesel engines

Hydrogen

Lubricants for Gasoline and Diesel engines

Coolants for combustion engines

### Literature

Lecturer notes

## Course: BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I [2141864]

**Coordinators:** A. Guber

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral examination: Elective Course (Duration: 30 minutes) or Main Course in combination with other lectures (Duration: 60 minutes)

Aids: none

### Conditions

None.

### Learning Outcomes

The lecture will first address relevant microtechnical manufacturing methods. Then, selected biomedical applications will be presented, as the increasing use of microstructures and microsystems in Life-Sciences und in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

### Content

Introduction into various microtechnical manufacturing methods: LIGA, Micro milling, Silicon Micromachining, Laser Microstructuring,  $\mu$ EDM, Metal-Etching  
Biomaterials, Sterilisation.

Examples of use in the life science sector: basic micro fluidic structures: micro channels, micro filters, micromixers, micropumps, microvalves, Micro and nanotiter plates, Microanalysis systems ( $\mu$ TAS), Lab-on-chip applications.

### Media

Lecture script

### Literature

Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005

M. Madou

Fundamentals of Microfabrication

Taylor & Francis Ltd.; Auflage: 3. Auflage. 2011

## Course: BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II [2142883]

**Coordinators:** A. Guber

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral: Elective Course (Duration: 30 minutes) or Main Course in combination with other lectures (Duration: 60 minutes)

Aids: none

### Conditions

None.

### Learning Outcomes

The lecture will first shortly address some relevant microtechnical manufacturing methods. Then, selected biomedical applications will be presented, as the increasing use of microstructures and microsystems in Life-Sciences und in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

### Content

Examples of use in Life-Sciences and biomedicine: Microfluidic Systems:

LabCD, Protein Crystallisation

Microarrays

Tissue Engineering

Cell Chip Systems

Drug Delivery Systems

Micro reaction technology

Microfluidic Cells for FTIR-Spectroscopy

Microsystem Technology for Anesthesia, Intensive Care and Infusion

Analysis Systems of Person's Breath

Neurobionics and Neuroprosthesis

Nano Surgery

### Media

Lecture script

### Literature

Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005

Buess, G.: Operationslehre in der endoskopischen Chirurgie, Band I und II;  
Springer-Verlag, 1994

M. Madou

Fundamentals of Microfabrication

## Course: BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III [2142879]

**Coordinators:** A. Guber

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral: Elective Course (Duration: 30 minutes) or Main Course in combination with other lectures (Duration: 60 minutes)

Aids: None

### Conditions

None.

### Learning Outcomes

The lecture will first shortly address some relevant microtechnical manufacturing methods. Then, selected biomedical applications will be presented, as the increasing use of microstructures and microsystems in Life-Sciences und in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

### Content

Examples of use in minimally invasive therapy  
 Minimally invasive surgery (MIS)  
 Endoscopic neurosurgery  
 Interventional cardiology  
 NOTES  
 OP-robots and Endosystems  
 License of Medical Products and Quality Management

### Media

Lecture script

### Literature

Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005  
 Buess, G.: Operationslehre in der endoskopischen Chirurgie, Band I und II;  
 Springer-Verlag, 1994  
 M. Madou  
 Fundamentals of Microfabrication

**Course: BUS-Controls [2114092]****Coordinators:** M. Geimer**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (20 min) taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

**Conditions**

Basic knowledge of electrical engineering is recommended. Programming skills are also helpful.

**Learning Outcomes**

The students will get an overview of the theoretic and practical functioning of different bus systems.

After the practical oriented lessons the students will be able to visualize the communication structure of different applications, design basic systems and evaluate the complexity of programming of the complete system.

**Content**

- Knowledge of the basics of data communication in networks
- Overview of the operating mode of current field buses
- Explicit observation of the operating mode and application areas of CAN buses
- Practical programming of an example application (hardware is provided)

**Literature****Elective literature:**

- Etschberger, K.: Controller Area Network, Grundlagen, Protokolle, Bausteine, Anwendungen; München, Wien: Carl Hanser Verlag, 2002.
- Engels, H.: CAN-Bus - CAN-Bus-Technik einfach, anschaulich und praxisnah dargestellt; Poing: Franzis Verlag, 2002.

**Remarks**

The course will be replenished by interesting lectures of professionals.

## Course: CAE-Workshop [2147175]

**Coordinators:** A. Albers, Assistenten

**Part of the modules:** Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 3              | Winter / Summer Term | de                   |

### Learning Control / Examinations

Depending on the manner in which the CAE-Workshop will be credited.

### Conditions

compulsory attendance

### Recommendations

We suggest this Workshop after 2 years of classes.

### Learning Outcomes

The students are able to ...

- name the purposes and limits of numerical simulation and optimization of the virtual product development.
- solve simple realistic tasks in the field of finite element analysis, multi-body-simulation and structure optimization with industrial common software (the content in winter and summer term is different).
- evaluate and to question the results of a simulation.
- identify and improve the mistakes of a simulation or optimization.

### Content

Content in the summer semester:

- introduction to the finite element analysis (FEA)
- stress and modal analysis of finite element models using Abaqus/CAE as a preprocessor and Abaqus solver
- introduction to topology and shape optimization
- creation and calculation of various optimization models with the optimization package TOSCA and the Abaqus solver

Content in the winter semester:

- introduction to the finite element analysis (FEA)
- stress and modal analysis of finite element models using Abaqus/CAE as a preprocessor and Abaqus solver
- introduction to multi-body simulation (MBS)
- preparation and running of multi-body simulation models. Coupling of the MBS and FEA to calculate hybrid multi-body simulation problems.

### Literature

The workshop script will be allocated at Ilias.

## Course: CFD for Power Engineering [2130910]

**Coordinators:** I. Otic

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

Oral exam, length: 30 minutes

### Conditions

None.

### Learning Outcomes

After completing the course students are able:

- to understand the fundamentals of computational fluid dynamics (CFD)
- to simulate turbulent flow with heat transfer using CFD
- to present, analyse and evaluate the simulation results.

### Content

This course is specified for both Bachelor and Master students, Power and Nuclear Engineering.

The course is aimed of giving the fundamental of Computational Fluid Dynamics (CFD) for energy technologies. Starting from the basic physical phenomena equations an overview on computational methods and turbulence modeling is given.

**Course: Chemical Fuels [2199115]****Coordinators:** G. Schaub**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

The examination results from the chosen module, otherwise:

oral examination

Duration: 30 min

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

After completing the course students can:

- Understand and describe the principles of production and upgrading of liquid fuels and their properties
- Understand fuel conversion processes (raw materials to products)
- Apply chemical equilibrium and reaction engineering fundamentals

**Content**

A. General aspects of chemical fuels

1. Introduction
  2. Characteristic properties of raw materials and fuel products
  3. Upgrading, conversion – process overview
- B. Petroleum and petroleum refining (example)
4. Properties of petroleum and petroleum products
  5. Refinery structures
  6. Separation processes in petroleum refining
  7. Chemical upgrading processes in petroleum refining
  8. Energy efficiency and pollution control
- C. Non-petroleum liquid fuels (example)
9. Liquid fuels from gaseous or solid feedstock
  10. Liquid fuels from biomass feedstock
- D. Gaseous and solid fuels
11. Example: fuel gas from coal and biomass

**Media**

Blackboard and slides/power point presentation

**Literature**

- 1) Course note package
- 2) Elvers B. (Ed.), Handbook of Fuels, Energy Sources for Transportation, Wiley VCH, Weinheim 2008
- 3) Jess A., Wasserscheid P., Chemical Technology, An Integral Textbook, Wiley VCH, Weinheim 2013

**Course: Computational Intelligence I [2106004]****Coordinators:** G. Bretthauer, R. Mikut**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination (1 hour)

Duration: 1 hours, also possible as an optional or part of a major subject

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students are able to apply the methods of fuzzy logic and fuzzy control efficiently. They know the basic mathematical foundations for the model design using fuzzy logic (membership functions, inference methods, defuzzification). In addition, they are able to design fuzzy controllers (Mamdani controllers and hybrid controllers with fuzzy-adaptive components) for practical applications.

**Content**

Terms and definitions Computational Intelligence, application fields and examples

Fuzzy logic and fuzzy sets

Fuzzification and membership functions

Inference: T-norms and -conorms, operators, aggregation, activation, accumulation

Defuzzification methods

Structures for fuzzy control

Software practice (fuzzyTECH) and applications (crane control)

**Literature**

Kiendl, H.: Fuzzy Control. Methodenorientiert. Oldenbourg-Verlag, München, 1997

Bandemer, H.; Gottwald, S.: Einführung in Fuzzy Methoden. Akademie-Verlag, Berlin, 1993

Zadeh, L.A.: Fuzzy Sets. Information and Control, 8, 338-353, 1965

Mikut, R.: Data Mining in der Medizin und Medizintechnik. Universitätsverlag Karlsruhe, Kapitel 5.5; 2008 (Internet)

Software: FuzzyTech (für die Übung)

**Course: Computational Intelligence II [2105015]**

**Coordinators:** G. Bretthauer, R. Mikut  
**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination (1 hour)

Duration: 1 hours, also possible as an optional or part of a major subject

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students are able to apply the methods of Artificial Neural Networks and Evolutionary Algorithms efficiently. They know the basic mathematical foundations and the goal-oriented design and the problem formulation for technical applications (selection of net structures for Artificial Neural Networks, optimization using Evolutionary Algorithms with coding of potential solutions for real-world applications as individuals).

**Content**

Terms and definitions, application fields and examples

Biological foundations of neural nets

Artificial Neural Nets: neurons, Multi-Layer-Perceptrons, Radial-Basis-Function nets, Kohonen maps, training strategies (Backpropagation, Levenberg-Marquardt)

Evolutionary Algorithms: Genetic Algorithms and Evolution Strategies, mutation, recombination, evaluation, selection, integration of local search strategies

Software practice (Gait-CAD, GLEAMKIT) and applications

**Literature**

S. Haykin: Neural Networks: A Comprehensive Foundation. Prentice Hall, 1999

T. Kohonen: Self-Organizing Maps. Berlin: Springer-Verlag, 1995

R. Rojas: Theorie der Neuronalen Netze. Berlin: Springer-Verlag, 1995

W. Jakob: Eine neue Methodik zur Erhöhung der Leistungsfähigkeit Evolutionärer Algorithmen durch die Integration lokaler Suchverfahren. Forschungszentrum Karlsruhe, 2004

H.-P. Schwefel: Evolution and Optimum Seeking. New York: John Wiley, 1995

H.J. Holland: Adaptation in Natural and Artificial Systems. Ann Arbor, 1975

R. Mikut: Data Mining in der Medizin und Medizintechnik. Universitätsverlag Karlsruhe, 2008 (Internet, Kapitel 5.6)

**Course: Computational Intelligence III [2106020]****Coordinators:** R. Mikut**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination (1 hour)

Duration: 1 hours, also possible as an optional or part of a major subject

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students are able to apply the methods of data analysis efficiently. They know the basic mathematical foundations for the analysis of single features and time series using classifiers, clustering and regression approaches. They are able to use various relevant methods as Bayes classifiers, Support Vector Machines, decision trees, fuzzy rulebases and they can adapt application scenarios (with data preprocessing and validation techniques) to real-world applications.

**Content**

Introduction and motivation

Terms and definitions (types of multidimensional features - time series and images, problem classes)

Application scenario: Problem formulation, feature extraction, evaluation, selection and transformation, distance measures, Bayes classifiers, Support-Vector-Machines, decision trees, clustering, regression, validation

Application (Software practice with Gait-CAD): Control of hand prostheses, energy prediction

**Literature**

Lecture notes (Internet)

Mikut, R.: Data Mining in der Medizin und Medizintechnik. Universitätsverlag Karlsruhe. 2008 (Internet)

Backhaus, K.; Erichson, B.; Plinke, W.; Weiber, R.: Multivariate Analysemethoden: Eine anwendungsorientierte Einführung. Berlin u.a.: Springer. 2000

Burges, C.: A Tutorial on Support Vector Machines for Pattern Recognition. Knowledge Discovery and Data Mining 2(2) (1998), S. 121–167

Tatsuoka, M. M.: Multivariate Analysis. Macmillan. 1988

Mikut, R.; Loose, T.; Burmeister, O.; Braun, S.; Reischl, M.: Dokumentation der MATLAB-Toolbox Gait-CAD. Techn. Ber., Forschungszentrum Karlsruhe GmbH. 2006 (Internet)

## Course: Decentrally controlled intralogistic systems [2117084]

**Coordinators:** K. Furmans, T. Baur

**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Winter term | de                   |

### Learning Control / Examinations

Certificate by colloquium with presentation

#### Conditions

presence obligatory

#### Recommendations

none

### Learning Outcomes

Students are able to:

- Model complex cinematic systems and use object-oriented programming for this purpose,
- Built experimental setups in a team for decentralized controlled intralogistic systems, choose appropriate system components and models and finally proof the function by using experiments.

### Content

- Introduction to material handling systems
- Construction of a model for decentralized logistic systems
- object-oriented programming with LabView
- Implementation of the model with Mindstorms

Presentation of the results

#### Media

Lego Mindstorms, PC

#### Literature

none

#### Remarks

none

## Course: Railways in the Transportation Market [2114914]

**Coordinators:** P. Gratzfeld

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

### Conditions

none

### Recommendations

none

### Learning Outcomes

The students learn about the entrepreneurial approach and viewpoint of railways. They comprehend key issues of the transport policy, regulatory as well as financial framework, and grasp strategic fields of action in international as well as intermodal market perspectives.

### Content

The lecture gives an overview about perspective, challenges and chances of rail systems in the national and European market. Following items will be discussed:

- Introduction and basics
- Rail reform
- Overview of Deutsche Bahn
- Development of infrastructure
- Regulation of railways
- Intra- and intermodal competition
- Field of actions in transport policy
- Railways and environment
- Trends in the transportation market
- Future of Deutsche Bahn, DB 2020
- Integration of traffic carriers
- International passenger and freight transportation

### Media

All material is available for download (Ilias-platform).

### Literature

none

### Remarks

For the dates please see special announcement on the website [www.bahnsystemtechnik.de](http://www.bahnsystemtechnik.de)

## Course: Finite Difference Methods for numerical solution of thermal and fluid dynamical problems [2153405]

**Coordinators:** C. Günther

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral

Duration: 30 minutes

no auxiliary means

### Conditions

None.

### Learning Outcomes

The students can apply the most important difference schemes for the numerical solution of steady and transient problems which are typical for thermal and fluid flow problems. They are able to discuss the most relevant properties of difference schemes such as consistency, stability and convergence. Furthermore, they can estimate the order of the numerical error and non-appearance of numerical oscillations.

### Content

The lecture initially presents an overview and then the most important difference schemes for the numerical solution of steady and transient problems which are typical for thermal and fluid flow problems. The most relevant properties of difference schemes at one side as consistency, stability and convergence, at the other side the order of the numerical error and non-appearance of numerical oscillations are described. Algorithms for the solution of coupled systems of equations, characteristic for fluid flow and thermal problems, are reviewed.

- Spatial and temporal discretization
- Properties of difference schemes
- Numerical stability, consistency, convergence
- Nonhomogeneous meshes
- Coupled and noninteracting calculation methods

**Course: Digital Control [2137309]****Coordinators:** M. Knoop**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination; duration: 30 minutes; no tools or reference materials may be used during the exam.

**Conditions**

Basic studies and preliminary examination; basic lectures in automatic control

**Learning Outcomes**

The lecture introduces key methods for the analysis and design of digital feedback control systems. Starting point is the discretisation of linear, continuous-time models. State space based and z-transform based controller design techniques are presented for discrete-time, single-input single-output systems. Furthermore, plants with dead-time and deadbeat design are covered.

**Content**

1. Introduction into digital control:

Motivation for digital implementation of controllers Structure of digital feedback control loops Sample and hold units

2. State space analysis and design:

Discretisation of continuous-time systems Discrete-time state space equations Stability - definition and criteria State feedback design by eigenvalue assignment PI state feedback controller Luenberger observer, separation theorem Systems with dead-time Deadbeat design

3. Analysis and design based on z-transform: z-transform - definition and theorems Control loop description in the z domain

Stability criteria Root locus controller design Transfer of continuous-time controllers into discrete-time controllers

**Literature**

- Lunze, J.: Regelungstechnik 2, 3. Auflage, Springer Verlag, Berlin Heidelberg 2005
- Unbehauen, H.: Regelungstechnik, Band 2: Zustandsregelungen, digitale und nichtlineare Regelsysteme. 8. Auflage, Vieweg Verlag, Braunschweig 2000
- Föllinger, O.: Lineare Abtastsysteme. 4. Auflage, R. Oldenbourg Verlag, München Wien 1990
- Ogata, K.: Discrete-Time Control Systems. 2nd edition, Prentice-Hall, Englewood Cliffs 1994
- Ackermann, J.: Abtastregelung, Band I, Analyse und Synthese. 3. Auflage, Springer Verlag, Berlin Heidelberg 1988

**Course: Designing with numerical methods in product development [2161229]****Coordinators:** E. Schnack**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination. Duration: 30 minutes.

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students are provided with a detailed overview of the numerical methods for product development in mechanical engineering. Account is taken of the fact that a modern development of products in mechanical engineering generally involves a multi-field approach: knowledge of thermodynamics, fluid mechanics, solid mechanics, electronics / electrics and magnetism are required. In addition, problems can be steady but are very often unsteady, i.e. time-dependent. All these aspects are incorporated into modern industrial software. In the lectures the fundamental methods used in the development of the software are introduced and discussed in detail. Students are provided with the tools to carry out the design process on a computer using existing industrial software. It is also worth noting that beside the finite element and the boundary element methods, structural optimisation with shape and topological optimisation must be taken into account. Structural optimisation will play an increasingly important role in the future.

**Content**

Overview of the numeric process: finite difference methods, finite volume methods. Finite element methods. Boundary element method (BEM). Thermodynamic processes. Flow dynamic processes. Solid dynamics. Non-linear field behaviour. These methods are summarised at the end of the course, and a holistic concept for design processes is developed.

**Literature**

Lecture notes (available in the administration office, building 10.91, rm. 310)

**Course: Designing with composites [2162255]****Coordinators:** E. Schnack**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination. Duration: 30 minutes.

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The aim is to gain understanding of laminated composite materials with a wide variety of applications in the aerospace and automotive industries. The terminology used for modern composites will be introduced and the students will gain an understanding of lamina, laminae and laminate. In addition they will gain understanding of the transformation properties between a single-layer and a multi-layer coordinate system. They will understand new aspects of composites such as the piezo-electric monitoring of composite materials.

**Content**

Short overview of the definition of modern composite materials. Fundamental structure of industrial composites. Definition of the mixture rules for fibre and matrix materials. Calculation of a wide variety of transformations between lamina, laminae and laminate for different coordinate systems. Derivation of the relevant differential equations for composites.

**Literature**

Lecture notes available in the administration office, building 10.91, rm. 310

## Course: Dynamics of the Automotive Drive Train [2163111]

**Coordinators:** A. Fidlin

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 4              | Winter term | de                   |

### Learning Control / Examinations

Oral examination

Duration: 30 min (optional subject)

20 min (major subject)

Means are not allowed

### Conditions

None.

### Recommendations

Powertrain Systems Technology A: Automotive Systems

Machine Dynamics

Vibration theory

### Learning Outcomes

- To obtain the basic skills in dynamic modelling of the vehicle powertrain including the most important components, driving situations and requirements

### Content

- Main components of the vehicle powertrain and their modelling
- Typical driving situations
- Problemoriented models for particular driving situations
- System analysis and optimization with respect to dynamic behavior

### Literature

- Dresig H. Schwingungen mechanischer Antriebssysteme, 2. Auflage, Springer, 2006
- Pfeiffer F., Mechanical System Dynamics, Springer, 2008
- Laschet A., Simulation von Antriebssystemen:Modellbildung der Schwingungssysteme und Beispiele aus der Antriebstechnik, Springer, 1988

## Course: Introduction in Human Factors Engineering [3110041]

**Coordinators:** B. Deml

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

oral exam for all compulsory core subjects (only in English)

Allowed resource materials: none

### Conditions

None.

### Learning Outcomes

Educational objectives: After having completed this course, the students are able to

- to classify fundamental principles of human work and to apply basic methods of human factors analysis.
- to evaluate and to design work-places according to psychological, physiological, anthropometric, safety-relevant, organisational, and technological aspects corresponding to work-scientific criteria.
- to evaluate and to design work-environments according to noise, lighting, climate, and mechanical vibrations corresponding to work-scientific criteria.
- to classify and to apply fundamental principles of human factors engineering (e. g. time studies). They are able to assess work-places and to derive payment systems for work-places.

to classify issues in labour law and they have obtained an overview of relevant industrial representations of the German labour world

### Content

1. Subjects and objects of human factors engineering
2. Fundamental principles of human work
3. Analysis methods of human work
4. Work-place design
5. Work-environment design
6. Labour economics
7. Labour law and organisation of industrial representations

### Literature

Handout and literature online ILIAS.

## Course: Introduction to the Finite Element Method [2162282]

**Coordinators:** T. Böhlke

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 4              | Summer term | de                   |

### Learning Control / Examinations

depending on choice according to actual version of study regulations

Additives as announced

Prerequisites are met by attestations during the associated lab course.

### Conditions

The institute decides about registration for the lab course (restricted number of participants).

### Recommendations

None.

### Learning Outcomes

The students can

- apply the most important tensorial operations in the framework of linear elasticity
- analyse the initial-boundary-value problem of linear thermal conductivity
- analyse the boundary-value problem of linear elasticity
- assess the spatial discretization for 3D problems
- derive the weak form for solving a boundary value problem
- evaluate solution methods for linear systems of equations
- choose an appropriate element-type for performing a finite-element-analysis for a given problem
- evaluate error estimations for the results of a finite-element-analysis
- autonomously perform a finite-element-analysis using the software ABAQUS

### Content

- introduction and motivation
- elements of tensor calculus
- the initial-boundary-value-problem of linear thermoconductivity
- the boundary-value-problem of linear elastostatic
- spatial discretization for 3D problems
- solution of the boundary-value-problem of elastostatic
- numerical solution of linear systems
- element types
- error estimation

### Literature

lecture notes

Fish, J., Belytschko, T.: A First Course in Finite Elements, Wiley 2007 (includes an introduction into ABAQUS)

**Course: Introduction to Nuclear Energy [2189903]****Coordinators:** X. Cheng**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content**

## Course: Introduction to Nuclear Engineering [2130974]

**Coordinators:** X. Cheng

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral examination; duration: 20 minutes

### Conditions

None.

### Learning Outcomes

This lecture is dedicated to students of mechanical engineering and other engineering bachelor or master degree courses. Goal of this lecture is it to get fundamental understanding of major aspects in nuclear engineering and nuclear energy.

### Content

1. Fission and energy production
2. fundamentals in reactor physics
3. classification and design of nuclear facilities
4. nuclear materials
5. reactor safety
6. radiation protection
7. fuel cycle
8. economical aspects
9. development tendencies in nuclear engineering

## Course: Introduction to Theory of Materials [2182732]

**Coordinators:** M. Kamlah

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

Engineering Mechanics; Advanced Mathematics

### Learning Outcomes

The student can judge for a problem to be computed, which constitutive model should be selected depending on choice of material and loading. For computation tools such as commercial finite element codes, the students can understand the documentation with respect to the implemented constitutive models, and they can make their choice based on their knowledge. The students have basic knowledge for the development of constitutive laws.

### Content

Following a brief introduction into continuum mechanics at small deformations, the classification into elastic, viscoelastic, plastic and viscoplastic constitutive models of solids is discussed. Then, one after the other, the four groups of elastic, viscoelastic, plastic and viscoplastic constitutive models are motivated and mathematically formulated. Their properties are demonstrated by means of elementary analytical solutions and examples.

### Literature

[1] Peter Haupt: Continuum Mechanics and Theory of Materials, Springer

[2] Lecture Notes

## Course: Introduction to the Mechanics of Composite Materials [2178734]

**Coordinators:** Y. Yang

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

Solid Mechanics

### Learning Outcomes

The students understand the fundamentals of the mechanical properties of composite materials. Based on this they can apply design rules for composite materials. They are able to analyze lightweight structures with respect to their mechanical properties.

### Content

- Introduction to composite materials, applied examples in the industry
- Micromechanical behaviour of a lamina
- Macromechanical behaviour of a lamina
- Macromechanical behaviour of a laminate (I): classical lamination theory
- Macromechanical behaviour of a laminate (II): stiffness / stress analysis
- Strength of laminates, failure criteria in laminates
- Optimization and Design of fiber reinforced composite materials

### Literature

[1] Robert M. Jones (1999), Mechanics of Composite Materials

[2] Valery V. Vasiliev & Evgeny V. Morozov (2001), Mechanics and Analysis of Composite Materials, ISBN: 0-08-042702-2

[3] Helmut Schürmann (2007), Konstruieren mit Faser-Kunststoffverbunden, Springer, ISBN: 978-3-540-72189-5 .

## Course: Introduction into Mechatronics [2105011]

**Coordinators:** G. Bretthauer, A. Albers

**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | de                   |

### Learning Control / Examinations

Written examination, oral examination or certification of participation depending on the "Studienplan" resp. "Prüfungs- und Studienordnung (SPO)".

### Conditions

none

### Learning Outcomes

The student has knowledge about the specific challenge of interdisciplinary collaboration within the framework of mechatronics. He is able to explain the origin, necessity and methodic implementation of interdisciplinary collaboration, to name the main difficulties as well as the special features within the development of mechatronic products from the point of view of development methodic.

The student has fundamental knowledge of modeling mechanical, hydraulically and electrically part systems and about suitable optimization methods.

The student knows the difference in use of the term "system" in mechatronic and mechanical use.

### Content

#### Part I: Modeling and optimization (Prof. Bretthauer)

Introduction

Architecture of mechatronic systems

Modeling of mechatronic systems

Optimization of mechatronic systems

Perspective

#### Part II: Development and design (Prof. Albers)

Introduction

Development method for mechatronic products

Examples

### Literature

Heimann, B.; Gerth, W.; Popp, K.: Mechatronik. Leipzig: Hanser, 1998

Isermann, R.: Mechatronische Systeme - Grundlagen. Berlin: Springer, 1999

Roddeck, W.: Einführung in die Mechatronik. Stuttgart: B. G. Teubner, 1997

Töpfer, H.; Kriesel, W.: Funktionseinheiten der Automatisierungstechnik. Berlin: Verlag Technik, 1988

Föllinger, O.: Regelungstechnik. Einführung in die Methoden und ihre Anwendung. Heidelberg: Hüthig, 1994

Bretthauer, G.: Modellierung dynamischer Systeme. Vorlesungsskript. Freiberg: TU Bergakademie, 1997

**Course: Introduction into the multi-body dynamics [2162235]****Coordinators:** W. Seemann**Part of the modules:** Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Written or oral exam.

Announcement 6 weeks prior to examination date.

**Conditions**

None.

**Learning Outcomes**

The students know different possibilities to describe the position und orientation of rigid bodies. They realize that during numerical integration of the kinematic differential equations singularities may arise which may be avoided if for example Euler-parameters are used. Holonomic as well as nonholonomic constraints and their effect on the structure of the differential equations are known. The description of the kinematic quantities in different reference systems can be done. The formulation of the moment of momentum using different reference frames for rotational velocity and inertia tensor is not a problem. Several methods for the derivation of equations of motion can be applied, especially for nonholonomic systems. The solution of equations of motion by numerical integration is understood in principle.

**Content**

The role of multibody systems in engineering, kinematics of a single rigid body, Kinematics of multibody systems, rotation matrix, angular velocity, derivatives in different reference systems, holonomic and non-holonomic constraints, Newton-Euler's equations, principle of d'Alembert, principle of virtual power, Lagrange's equations, Kane's equations, structure of the equations of motion

**Literature**

Wittenburg, J.: Dynamics of Systems of Rigid Bodies, Teubner Verlag, 1977

Roberson, R. E., Schwertassek, R.: Dynamics of Multibody Systems, Springer-Verlag, 1988

de Jal'on, J. G., Bayo, E.: Kinematik and Dynamic Simulation of Multibody System.

Kane, T.: Dynamics of rigid bodies.

## Course: Introduction to modeling of aerospace systems [2154430]

**Coordinators:** G. Schlöffel

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral

Duration: 30 min

no auxiliary means

### Conditions

none

### Recommendations

basic skills in mathematics, physics and fluid dynamics

### Learning Outcomes

Students attending this lecture will be able to,

- give an outline of the common methods of modeling the flight of aerospace systems,
- describe the different phases of flight of an aerospace system launching from earth,
- handle and compute the physics and its particular impact on the aerospace system during the different phases of flight,
- discriminate and treat in particular the effects of gravitation, propulsion and aerodynamics,
- characterize and describe possible flight paths and orbits,
- implement in Matlab/Simulink the fundamental equations of motion with respect to the simulation of an aerospace system

### Content

This lecture covers the following topics:

- Reference and coordinate systems and their transformations
- Newton-Euler-Equations of motion
- Gravitation
- Propulsion of aerospace systems
- Aerodynamics
- Trajectories and Orbits
- Re-entry
- Implementation of a Matlab/Simulink simulation

### Literature

- P. H. Zipfel: Modeling and Simulation of Aerospace Vehicle Dynamics. American Institute of Aeronautics and Astronautics (AIAA), Reston 2007. ISBN 978-1563478758
- A. Tewari: Atmospheric and Space Flight Dynamics. Birkhäuser, Boston 2007. ISBN 978-0-8176-4373-7
- W. Ley, K. Wittmann, W. Hallmann (Hrsg.): Handbuch der Raumfahrttechnik. Hanser, München 2011. ISBN 978-3446424067
- W. Büdeler: Geschichte der Raumfahrt. Edition Helmut Sigloch, Künzelsau 1999. ISBN 978-3893931941

**Course: Introduction to numerical mechanics [2161226]****Coordinators:** E. Schnack**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination. Duration: 30 minutes.

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Introduction to the numerical treatment of mechanical problems with finite element methods (FEM) based on technical mechanics. Derivation of spring, rod and beam systems. Development of simple elements of continuum mechanics, more advanced finite element techniques such as hybrid methods and boundary element methods. Through detailed deductions in the lectures, the students are then able to develop their own codes for engineering software. The specific aim of this course is a deeper understanding of the construction of numerical processes, so that the students are able to develop software independently. The aim is not to learn how to work with existing software, as this is an area which is continually developing. The emphasis will therefore be placed on the detailed theoretical calculations behind the methods.

**Content**

Spring, rod and beam elements. Introduction to matrix calculations. Derivation of numerical process. Principles of virtual work. Variation principles. Finite element algorithms, boundary element algorithms.

**Literature**

Script (available in administration office, building 10.91, rm. 310).

## Course: Introduction to Nonlinear Vibrations [2162247]

**Coordinators:** A. Fidlin

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 7            | 4              | Summer term | de                   |

### Learning Control / Examinations

Oral examination

Duration: 30 min (optional subject)

20 min (major subject)

Means are not allowed

### Conditions

None.

### Recommendations

Vibration theory, mathematical methods of vibration theory, dynamic stability

### Learning Outcomes

The students

- know the most usual nonlinear effects
- know the minimal models for these effects
- are able to apply perturbation methods for the analysis of nonlinear systems
- know basics of the bifurcation theory
- are able to identify dynamic chaos

### Content

- dynamic systems
- basic ideas of asymptotic methods
- perturbation methods: Linstedt-Poincare, averaging, multiple scales
- limit cycles
- nonlinear resonance
- basics of the bifurcation analysis, bifurcation diagrams
- types of bifurcations
- discontinuous systems
- dynamic chaos

### Literature

- Hagedorn P. Nichtlineare Schwingungen. Akademische Verlagsgesellschaft, 1978.
- Nayfeh A.H., Mook D.T. Nonlinear Oscillation. Wiley, 1979.
- Thomsen J.J. Vibration and Stability, Order and Chaos. McGraw-Hill, 1997.

- Fidlin A. Nonlinear Oscillations in Mechanical Engineering. Springer, 2005.
- Bogoliubov N.N., Mitropolskii Y.A. Asymptotic Methods in the Theory of Nonlinear Oscillations. Gordon and Breach, 1961.
- Nayfeh A.H. Perturbation Methods. Wiley, 1973.
- Sanders J.A., Verhulst F. Averaging methods in nonlinear dynamical systems. Springer-Verlag, 1985.
- Blekhman I.I. Vibrational Mechanics. World Scientific, 2000.
- Moon F.C. Chaotic Vibrations – an Introduction for applied Scientists and Engineers. John Wiley & Sons, 1987.

**Course: Electric Power Generation and Power Grid [2300002]****Coordinators:** B. Hoferer**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Winter term | en                   |

**Learning Control / Examinations**

oral examination

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

After completing the course, the students have theoretical fundamentals and solid understanding of electrical power engineering. The students are able to analyse problems in the field of power generation and power grid and to develop approaches to these problems.

**Content**

Power generation fundamental lecture. The lecture covers the entire topic of power generation from conversion of primary energy resources in coal fired power plants and nuclear power plants to utilisation of renewable energy. The lecture gives a review of the physical fundamentals, technical-economical aspects and potential for development of power generation both conventional generation and renewable generation. The lecture covers basics in power grids.

**Literature**

Material is available at the beginning of the lecture. Literature: Schwab; Elektroenergiesysteme.

## Course: Electrical Machines [23315]

**Coordinators:** M. Doppelbauer

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

oral examination;  
duration: 20-30 minutes

### Conditions

None

### Recommendations

Candidates should have attended lectures and exercises.

### Learning Outcomes

After completing the course the students are able to:

- understand the basic processes of mechanical and electrical energy conversion,
- specify and calculate electrical transformers,
- understand the basic processes of the generation of rotating magnetic fields,
- describe the operating principles and characteristics of asynchronous and synchronous electrical machines,
- identify the sources of torque and noise related problems of electric machines,
- understand the behavior of mechanical transmission elements and typical machines loads like fans, compressors and conveyors and specify a suitable electric machines accordingly,
- understand the mechanisms of losses and energy efficiency of electric machines.

### Content

- Electrical machine basics
- Magnetic circuit basics
- Permanent magnets
- Rotating field windings
- DC (commutator) machines
- Synchronous machines
- Asynchronous machines

### Media

Blackboard and powerpoint presentation. Practical examples as needed.

### Literature

Course note packet

- H. A. Toliyat, G. B. Kliman: **Handbook of Electric Motors**, CRC Press, Taylor&Francis Group, 2004
- T. Wildi: **Electrical Machines, Drives and Power Systems**, Prentice Hall, 2005
- J.R. Hendershot, T. Miller: **Design of Brushless Permanent-Magnet Motors**, Magna Physics Publishing and Oxford University Press, 1994

- P.L. Alger: **The Nature of Polyphase Induction Machines**, John Wiley&Sons, Inc. and Chapman&Hall, Ltd., 1951
- Rolf Fischer: **Elektrische Maschinen** (German language only), Carl Hanser Verlag, 2009

**Remarks**

None

## Course: Electrical Power Transmission and Grid Control [2199120]

**Coordinators:** T. Leibfried

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | en                   |

### Learning Control / Examinations

The examination results from the chosen module, otherwise:

Power Point Presentation worked out and presented by the student about special topics presented in the lecture, each student will get his own topic for presentation

Duration: 15-20 minutes plus discussion

### Conditions

none

### Recommendations

none

### Learning Outcomes

After completing the course students

- can design an AC transmission system and describe its limitations
- can do the basic design an HVDC power transmission system and are able to describe the functional components, their necessity and working principle.
- can design an appropriate FACTS system and are able to describe different alternatives and know their working principle

They understand the basic working principle of the power grid control system.

### Content

Characteristic and limitations of the AC power transmission in the HV and MV grid. HVDC transmission system using LCC technology, FACTS (Flexible AC transmission Systems), Grid control principle and system.

### Media

Blackboard and Powerpoint presentation

### Literature

Course note packet

P. Kundur

“Power System Stability and Control“

McGraw-Hill Inc., 1994, ISBN 0-07-035958-X

N. G. Hingorani, L. I. Gyugyi

“Understanding FACTS“

Institute of Electrical and Electronics Engineers Inc., 2000, ISBN 0-7803-3455-8

**Course: Electric Rail Vehicles [2114346]****Coordinators:** P. Gratzfeld**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The students know the history of electric traction in railway transportation from the very beginning to modern vehicles with three-phase traction drives.

They know the basics of railway transportation, vehicle dynamics and wheel-rail-contact and can deduct the requirements for electric rail vehicles out of it.

They understand purpose, design and functionality of electric traction drives.

They learn about the different systems of traction power supply with its advantages and disadvantages.

They are informed about actual concepts and new developments in the field of electric railway vehicles.

**Content**

History of electric traction with railway vehicles, economic impact

Vehicle dynamics: running resistance, tractive effort diagram, running cycles

Wheel-rail-contact

Electric drives: traction motors, power conversion, drives for vehicles at dc and ac lines, dieselelectric vehicles, multi system vehicles, axle drives, transmission of tractive effort to the rails

Traction power supply: networks, substations, inductive power supply, energy management

Modern vehicle concepts for mass transit and main line

**Media**

All slides are available for download (Ilias-platform).

**Literature**

A bibliography is available for download (Ilias-platform).

**Course: Electrical Engineering II [23224]****Coordinators:** W. Menesklou**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of a written exam (120 min) taking place in the recess period (according to Section 4(2), 1 of the examination regulation). The examination takes place in every semester. Re-examinations are offered at every ordinary examination date.

**Conditions**

The module Electrical Engineering [WI1ING4] has to be completed beforehand.

**Learning Outcomes**

The student knows and understands basic components and techniques of electrical engineering.

**Content**

This course introduces undergraduate students of Industrial Engineering and Management into topics of advanced electrical engineering like electrical instrumentation, semiconductors, control engineering and electric motors. Within the lecture, assignments to the curriculum are discussed and are used for preparation for written examination.

**Media**

Online material is available at <http://www.iwe.kit.edu>

**Literature**

Online material is available on <http://www.iwe.kit.edu/>

Elective literature:

Will be announced during the lecture.

**Course: Elements of Technical Logistics [2117096]****Coordinators:** M. Mittwollen, Madzharov**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

**Learning Control / Examinations**

after each lesson period; oral / written (if necessary) =&gt; (look at "Studienplan Maschinenbau", latest version)

**Conditions**

None.

**Recommendations**

previous / parallel visit of LV 21177095 "Grundlagen der Technischen Logistik"

**Learning Outcomes**

Students are able to:

- Describe elements and systems of technical logistics,
- Model and calculate structures and functions of special conveying machines,
- Describe interdependence of material flow systems and technique quantitatively and qualitatively and
- Equip material flow systems with appropriate machines.

**Content**

material flow systems and their (conveying) technical components

mechanical behaviour of conveyors;

structure and function of conveyor machines; elements of intralogistics (belt conveyor, racks, automatic guided vehicles, fan-in, bifurcation, and etc.)

sample applications and calculations in addition to the lectures inside practical lectures

**Media**

supplementary sheets, projector, blackboard

**Literature**

recommendations during lectures

## Course: Elements of Technical Logistics and Project [2117097]

**Coordinators:** M. Mittwollen, Madzharov

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

### Learning Control / Examinations

Lesson: after each lesson period; oral / written (if necessary) => (look at "Studienplan Maschinenbau"); (counts two-thirds);

Project: presentation, marked (counts one third)

### Conditions

None.

### Recommendations

previous / parallel visit of LV 21177095 "Grundlagen der Technischen Logistik"

### Learning Outcomes

Students are able to:

- Describe elements and systems of technical logistics,
- Model and calculate structures and functions of special conveying machines,
- Describe interdependence of material flow systems and technique quantitatively and qualitatively,
- Equip material flow systems with appropriate machines and
- Judge about systems in place and justify it in front of subject related persons.

### Content

mechanical behaviour of conveyors;

structure and function of conveyor machines; elements of intralogistics (belt conveyor, racks, automatic guided vehicles, fan-in, bifurcation, and etc.)

sample applications and calculations in addition to the lectures inside practical lectures

Self manufacturing of a project report to recesses the topic.

### Media

supplementary sheets, projector, blackboard

### Literature

recommendations during lectures

## Course: Energy and Process Technology I [2157961]

**Coordinators:** H. Bauer, A. Velji, H. Wirbser, C. Höfler  
**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4,5          | 4              | Winter term | de                   |

### Learning Control / Examinations

#### Conditions

None.

#### Learning Outcomes

The students are able to:

- describe and calculate the basic physical-technical processes
- apply the mathematical and thermodynamical description
- reflect on and explain the diagrams and schematics
- comment on diagrams
- explain the functionality of gas and steam turbines and their components
- name the applications of thermal turbomachinery and their role in the field of electricity generation and propulsion technology

#### Content

The last third of the lecture deals with the topic **Thermal Turbomachinery**. The basic principles, the functionality and the scope of application of gas and steam turbines for the generation of electrical power and propulsion technology are addressed.

## Course: Energy and Process Technology II [2170832]

**Coordinators:** C. Höfler, H. Wirbser

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 4              | Summer term | de                   |

### Learning Control / Examinations

#### Conditions

None.

#### Learning Outcomes

The students are able to:

- discuss and evaluate energy resources and reserves and their utility
- review the use of energy carriers for electrical power generation
- explain the concepts and properties of power-heat cogeneration, renewable energy conversion and fuel cells and their fields of application
- comment on and compare centralized and decentralized supply concepts
- calculate the potentials, risks and economic feasibility of different strategies aiming at the protection of resources and the reduction of CO<sub>2</sub> emissions
- name and judge on the options for solar energy utilization
- discuss the potential of geothermal energy and its utilization

#### Content

**Thermal Turbomaschinery** - In the first part of the lecture deals with energy systems. Questions regarding global energy resources and their use, especially for the generation and provision of electrical energy, are addressed. Common fossile and nuclear power plants for the centralized supply with electrical power as well as concepts of power-heat cogeneration for the decentralized electrical power supply by means of block-unit heat and power plants, etc. are discussed. Moreover, the characteristics and the potential of renewable energy covnersion concepts, such as wind and hydro-power, photovoltaics, soalr heat, geothermal energy and fuel cells are compare and evaluated. The focus is on the description and calification of the potentials, the risks and the economic feasibility of the different strategies aimed to protect resources and reduce CO<sub>2</sub> emissions.

## Course: Energy efficient intralogistic systems [2117500]

**Coordinators:** F. Schönung

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral, 30 min, examination dates after the end of each lesson period

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

Students are able to:

- Describe and choose basic measures to enhance energy efficiency,
- Specify this measures considering material handling processes like
  - steady conveyors,
  - unsteady conveyors,
  - as well as the necessary drives,
- Model based on this material handling systems and calculate their energy efficiency and
- Choose resource efficient material handling systems.

### Content

The main focuses of the course are:

- green supply chain
- processes in Intralogistic systems
- evaluation of energy consumption of conveyors
- modeling of conveying systems
- methods for energy savings
- approaches for energy efficiency increasing of continuous and discontinuous conveyors
- dimensioning energy efficient drives
- new approaches for resource efficient conveying systems.

### Media

presentations, black board

### Literature

None.

### Remarks

none

## Course: Energy Systems I: Renewable Energy [2129901]

**Coordinators:** R. Dagan

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | de                   |

### Learning Control / Examinations

Oral examination – as an elective course 30 minutes, in combination with Energiesysteme II or other courses within the energy courses, as a major course 1 hour

### Conditions

None.

### Learning Outcomes

The student knows the principles of the feasibility of energy gain by means of renewable energies, in particular the solar energy.

### Content

The course deals with fundamental aspects of renewable energies.

1. The first part deals with the basic concepts of absorbing solar beams, in an efficient manner accounting for the minimization of heat losses. In this context, selective topics on Thermodynamics as well as fluid dynamics are introduced. In the second part few applications are discussed and optimizations techniques of solar collectors construction and their heat transfer are presented.
2. The use of solar energy as a source for heat generation is followed by the idea of electricity generation. Introductory aspects of Photovoltaic technologies are illuminated.
3. The last part presents additional regenerative energy sources such as wind and geothermal energy.

## Course: Energy Systems II: Nuclear Energy and Reactor Technology [2130921]

**Coordinators:** A. Badea

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

### Learning Control / Examinations

oral examination, 30 min.

### Conditions

none

### Recommendations

none

### Learning Outcomes

The students are familiar with nuclear, cooling and control engineering calculation methods for the design of nuclear power plants with nuclear fission reactors and with the safety standards in the nuclear industry.

### Content

nuclear fission & fusion,  
 chain reactions,  
 moderation,  
 light-water reactors,  
 reactor safety,  
 reactor dynamics,  
 design of nuclear reactors,  
 breeding processes,  
 nuclear power systems of generation IV

### Literature

slides, lecture notes

Dieter Smidt, Reaktortechnik, 1971 by G. Braun, ISBN 3 7650 2003 6;

D.G. Cacuci, Handbook of Nuclear Engineering, Springer 2010, ISBN 978-0-387-98130-7

**Course: Organ support systems [2106008]****Coordinators:** C. Pylatiuk**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral, also possible as an optional or part of a major subject

**Conditions**

None.

**Recommendations**

Fundamentals of medicine

**Learning Outcomes**

Students have fundamental knowledge about functionality of organ support systems and its components. An analysis of historical developments can be done and limitations of current systems can be found. The limits and possibilities of transplantations can be elaborated.

**Content**

- Introduction: Definitions and classification of organ support and replacement.
- Special topics: acoustic and visual prostheses, exoskeletons, neuroprostheses, tissue-engineering, hemodialysis, heart-lung machine, artificial hearts, biomaterials.

**Literature**

- Jürgen Werner: Kooperative und autonome Systeme der Medizintechnik: Funktionswiederherstellung und Organersatz. Oldenbourg Verlag.
- Rüdiger Kramme: Medizintechnik: Verfahren - Systeme – Informationsverarbeitung. Springer Verlag.
- E. Wintermantel, Suk-Woo Ha: Medizintechnik. Springer Verlag.

**Course: Experimental Fluid Mechanics [2154446]****Coordinators:** J. Kriegseis**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

no auxiliary means

**Conditions**

None.

**Recommendations**

Fundamental Knowledge about Fluid Mechanics

**Learning Outcomes**

The students can describe the relevant physical principles of experimental fluid mechanics. They are qualified to comparatively discuss the introduced measurement techniques. Furthermore, they are able to distinguish (dis-)advantages of the respective approaches. The students can evaluate and discuss measurement signal and data obtained with the common fluid mechanical measuring techniques.

**Content**

This lecture focuses on experimental methods of fluid mechanics and their application to solve flow problems of practical relevance. In addition, measurement signals and data, obtained with the discussed measuring techniques, are evaluated, presented and discussed.

The lecture covers a selection of the following topics:

- measuring techniques and measureable quantities
- measurements in turbulent flows
- pressure measurements
- hot wire measurements
- optical measuring techniques
- error analysis
- scaling laws
- signal and data evaluation

**Media**

Slides, chalk board, overhead

**Literature**

Tropea, C., Yarin, A.L., Foss, J.F.: Springer Handbook of Experimental Fluid Mechanics, Springer 2007  
 Spurk, J.H.: Fluid Mechanics, Springer, 1997

## Course: Metallographic Lab Class [2175590]

**Coordinators:** K. von Klinski-Wetzel

**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 3              | Winter / Summer Term |                      |

### Learning Control / Examinations

Colloquium with every experiment, Laborjournal

### Conditions

basic knowledge in materials science (e.g. lecture materials science I and II)

### Learning Outcomes

The students in this lab class gain are able to perform standard metallographic preparations and are able to apply standard software for quantitative microstructural analyses. Based on this the student can interpret unetched as well as etched microstructures with respect to relevant microstructural features. They can draw concluding correlations between heat treatments, ensuing microstructures and the resulting mechanical as well as physical properties of the investigated materials.

### Content

Light microscope in metallography

metallographic sections of metallic materials

Investigation of the microstructure of unalloyed steels and cast iron

Microstructure development of steels with accelerated cooling from the austenite area

Investigation of microstructures of alloyed steels

Investigation of failures quantitative microstructural analysis

Microstructural investigation of technically relevant non-ferrous metals  
(e. g. copper-, aluminium-, nickel-, titanium-and tin-based alloys)

### Literature

E. Macherauch: Praktikum in Werkstoffkunde, 10th edition, 1992

H. Schumann: Metallographie, 13th edition, Deutscher Verlag für Grundstoffindustrie, 1991

Literature List will be handed out with each experiment

## Course: The Management of R&D Projects with Case Studies [2581963]

**Coordinators:** H. Schmied

**Part of the modules:** Elective Subject Economics/Law (p. 61)[MSc-Modul 12, WF WR]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 4              | Winter / Summer Term | de                   |

### Learning Control / Examinations

The assessment consists of a written exam (60 minutes) (following §4(2), 1 of the examination regulation). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

### Conditions

None.

### Learning Outcomes

- Students shall be able to discuss different tasks of R&D-management.
- Students shall be able to apply common approaches to solve these general problems.

### Content

- The communication between R&D, production and marketing.
- Problems concerning measuring the productivity of the R&D system.
- Methods for improving the productivity of R&D systems.
- Planning of R&D projects with the help of the Communication-Matrix-Methods for controlling R&D projects' progress.
- The marketing of scientific skills.
- The communication matrix as a tool for the implementation of simultaneous engineering.
- Case studies.

### Literature

will be announced in the course

## Course: Handling Characteristics of Motor Vehicles I [2113807]

**Coordinators:** H. Unrau

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Verbally

Duration: 30 up to 40 minutes

Auxiliary means: none

#### Conditions

None.

#### Recommendations

None.

### Learning Outcomes

The students know the basic connections between drivers, vehicles and environment. They can build up a vehicle simulation model, with which forces of inertia, aerodynamic forces and tyre forces as well as the appropriate moments are considered. They have proper knowledge in the area of tyre characteristics, since a special meaning comes to the tire behavior during driving dynamics simulation. Consequently they are ready to analyze the most important influencing factors on the driving behaviour and to contribute to the optimization of the handling characteristics.

### Content

1. Problem definition: Control loop driver - vehicle - environment (e.g. coordinate systems, modes of motion of the car body and the wheels)
2. Simulation models: Creation from motion equations (method according to D'Alembert, method according to Lagrange, programme packages for automatically producing of simulation equations), model for handling characteristics (task, motion equations)
3. Tyre behavior: Basics, dry, wet and winter-smooth roadway

### Literature

1. Willumeit, H.-P.: Modelle und Modellierungsverfahren in der Fahrzeugdynamik, B. G. Teubner Verlag, 1998
2. Mitschke, M./Wallentowitz, H.: Dynamik von Kraftfahrzeugen, Springer-Verlag, Berlin, 2004
3. Gnadler, R.; Unrau, H.-J.: Reprint collection to the lecture Handling Characteristics of Motor Vehicles I

## Course: Handling Characteristics of Motor Vehicles II [2114838]

**Coordinators:** H. Unrau

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

#### Conditions

None.

#### Recommendations

None.

### Learning Outcomes

The students have an overview of common test methods, with which the handling of vehicles is gauged. They are able to interpret results of different stationary and transient testing methods. Apart from the methods, with which e.g. the driveability in curves or the transient behaviour from vehicles can be registered, also the influences from cross-wind and from uneven roadways on the handling characteristics are well known. They are familiar with the stability behavior from single vehicles and from vehicles with trailer. Consequently they are ready to judge the driving behaviour of vehicles and to change it by specific vehicle modifications.

### Content

1. Vehicle handling: Bases, steady state cornering, steering input step, single sine, double track switching, slalom, cross-wind behavior, uneven roadway

2. stability behavior: Basics, stability conditions for single vehicles and for vehicles with trailer

### Literature

1. Zomotor, A.: Fahrwerktechnik: Fahrverhalten, Vogel Verlag, 1991

2. Mitschke, M./Wallentowitz, H.: Dynamik von Kraftfahrzeugen, Springer-Verlag, Berlin, 2004

3. Gnadler, R. Unrau, H.-J.: Reprint collection to the lecture Handling Characteristics of Motor Vehicles II

**Course: Vehicle Comfort and Acoustics I [2113806]****Coordinators:** F. Gauterin**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

**Conditions**

Can not be combined with lecture [2114856]

**Recommendations**

None.

**Learning Outcomes**

The students know what noises and vibrations mean, how they are generated, and how they are perceived by human beings.

They have knowledge about the requirements given by users and the public. They know which components of the vehicle are participating in which way on noise and vibration phenomenon and how they could be improved. They are ready to apply different tools and methods to analyze relations and to judge them. They are able to develop the chassis regarding driving comfort and acoustic under consideration of goal conflicts.

**Content**

1. Perception of noise and vibrations
3. Fundamentals of acoustics and vibrations
3. Tools and methods for measurement, computing, simulation and analysis of noise and vibrations
4. The relevance of tire and chassis for the acoustic and mechanical driving comfort: phenomena, influencing parameters, types of construction, optimization of components and systems, conflict of goals, methods of development

An excursion will give insights in the development practice of a car manufacturer or a system supplier.

**Literature**

1. Michael Möser, Technische Akustik, Springer, Berlin, 2005
2. Russel C. Hibbeler, Technische Mechanik 3, Dynamik, Pearson Studium, München, 2006
3. Manfred Mitschke, Dynamik der Kraftfahrzeuge, Band B: Schwingungen, Springer, Berlin, 1997

The script will be supplied in the lectures

**Course: Vehicle Comfort and Acoustics II [2114825]****Coordinators:** F. Gauterin**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

**Conditions**

Can not be combined with lecture [2114857]

**Recommendations**

None.

**Learning Outcomes**

The students have knowledge about the noise and vibration properties of the chassis components and the drive train. They know what kind of noise and vibration phenomena do exist, what are the generation mechanisms behind, which components of the vehicle participate in which way and how could they be improved. They have knowledge in the subject area of noise emission of automobiles: Noise impact, legal requirements, sources and influencing parameters, component and system optimization, target conflicts and development methods. They are ready to analyze, to judge and to optimize the vehicle with its single components regarding acoustic and vibration phenomena. They are also able to contribute competently to the development of a vehicle regarding the noise emission.

**Content**

1. Summary of the fundamentals of acoustics and vibrations
2. The relevance of road surface, wheel imperfections, springs, dampers, brakes, bearings and bushings, suspensions, engines and drive train for the acoustic and mechanical driving comfort:
  - phenomena
  - influencing parameters
  - types of construction
  - optimization of components and systems
  - conflicts of goals
  - methods of development
3. Noise emission of motor vehicles
  - noise stress
  - sound sources and influencing parameters
  - legal restraints
  - optimization of components and systems
  - conflict of goals
  - methods of development

**Literature**

The script will be supplied in the lectures.

## Course: Introduction to Automotive Lightweight Technology [2113102]

**Coordinators:** F. Henning

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

verbally

duration: 20 - 30 min

auxiliary means: none

### Conditions

none

### Recommendations

none

### Learning Outcomes

Students learn that lightweight design is a process of realizing a demanded function by using the smallest possible mass. They understand lightweight construction as a complex optimization problem with multiple boundary conditions, involving competences from methods, materials and production.

Students learn the established lightweight strategies and ways of construction. They know the metallic materials used in lightweight construction and understand the relation between material and vehicle body.

### Content

strategies in lightweight design

shape optimization, light weight materials, multi-materials and concepts for lightweight design

construction methods

differential, integral, sandwich, modular, bionic

body construction

shell, space frame, monocoque

metallic materials

steel, aluminium, magnesium, titan

**Course: Vehicle Mechatronics I [2113816]****Coordinators:** D. Ammon**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Written examination

Duration: 90 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students have an overview of the system science field of mechatronics and its application in the area of vehicle conception, especially in the context of vehicle system dynamics. They know the tools and methods for a systematic analysis, conception, and design of mechatronic systems, focussing on mechatronically extended suspension systems. They are ready to analyze, to judge and to optimize mechatronic systems.

**Content**

1. Introduction: Mechatronics in vehicle technology
2. Vehicle Control systems  
Brake- and traction controls (ABS, ASR, automated power train controls)  
Active and semiactive suspension systems, active stabilizer bars  
Vehicle dynamics controls, driver assistance systems
3. Modelling technology  
Mechanics - multi body dynamics  
Electrical and electronical systems, control systems  
Hydraulics  
Interdisciplinary coupled systems
4. Computer simulation technology  
Numerical integration methods  
Quality (validation, operating areas, accuracy, performance)  
Simulator-coupling (hardware-in-the-loop, software-in-the-loop)
5. Systemdesign (example: brake control)  
Demands, requirements (funktion, safety, robustness)  
Problem setup (analysis - modelling - model reduction)  
Solution approaches  
Evaluation (quality, efficiency, validation area, concept ripeness)

**Literature**

1. Ammon, D., Modellbildung und Systementwicklung in der Fahrzeugdynamik, Teubner, Stuttgart, 1997
2. Mitschke, M., Dynamik der Kraftfahrzeuge, Bände A-C, Springer, Berlin, 1984ff
3. Miu, D.K., Mechatronics - Electromechanics and Contromechanics, Springer, New York, 1992
4. Popp, K. u. Schiehlen, W., Fahrzeugdynamik - Eine Einführung in die Dynamik des Systems Fahrzeug-Fahrweg, Teubner, Stuttgart, 1993
5. Roddeck, W., Einführung in die Mechatronik, Teubner, Stuttgart, 1997
6. Zomotor, A., Fahrwerktechnik: Fahrverhalten, Vogel, Würzburg, 1987

## Course: Basics and Methods for Integration of Tires and Vehicles [2114845]

**Coordinators:** G. Leister

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

### Learning Control / Examinations

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

### Conditions

Knowledge in automotive engineering

### Learning Outcomes

The students are informed about the interactions of tires, chassis and road. They have an overview of the processes regarding the tire development. They have knowledge of the physical relationships. They are ready to analyze and to judge the mentioned interactions. They are able to participate competently in the chassis development.

### Content

1. The role of the tire in a vehicle
2. Tire geometrie, Package and load capacity, Book of requirement
3. Mobility strategy, Minispare, runflat systems and repair kit.
4. Project management: Costs, weight, planning, documentation
5. Tire testing and tire properties: Forces and Moments
6. Tire modes and sound
7. Tire pressure: Indirect and direct measuring systems
8. Tire testing subjective and objective

### Literature

Manuscript to the lecture

**Course: Automotive Vision [2138340]****Coordinators:** C. Stiller, M. Lauer**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes

no reference materials

**Conditions**

Fundamentals in measurement, system and control theory, e.g. from the lecture "Measurement and Control Systems"

**Learning Outcomes**

Machine perception and interpretation of the environment for the basis for the generation of intelligent behaviour. Especially visual perception opens the door to novel automotive applications. First driver assistance systems can already improve safety, comfort and efficiency in vehicles. Yet, several decades of research will be required to achieve an automated behaviour with a performance equivalent to a human operator. The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Machine vision, vehicle kinematics and advanced information processing techniques are presented to provide a broad overview on 'Being vehicles'. Application examples from cutting-edge and future driver

assistance systems illustrate the discussed subjects.

**Content**

1. Driver assistance systems
2. Image acquisition and discretization
3. Image signal processing
4. Stochastic image models
5. Stereo vision and image sequence processing
6. Tracking
7. Lane recognition
8. Obstacle recognition

**Literature**

TBA

**Course: Composites for Lightweight Design [2114053]****Coordinators:** F. Henning**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

verbally

duration: 20 - 30 min

auxiliary means: none

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Students know different polymer resin materials and fiber materials and can deduce their character and use.

They understand the reinforcing effect of fibers in a matrix surrounding as well as the tasks of the single components in a compound. They know about the influence of the length of fibers, their mechanical characters and performance in a polymer matrix compound.

Student know the important industrial production processes for continuous and discontinuous reinforced polymer matrix compounds.

**Content**

Physical connections of fiber reinforcement

Use and examples

automotive construction

transport

Energy and construction

sport and recreation

resins

thermoplastics

duromeres

mechanisms of reinforcements

glas fibers

carbon fibers

aramid fibers

natural fibers

semi-finished products - textiles

process technologies - prepregs

recycling of composites

**Course: FEM Workshop – constitutive laws [2183716]****Coordinators:** K. Schulz, D. Weygand**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral examination in the elective module MSc, otherwise no grading  
 solving of a FEM problem  
 preparation of a report  
 preparation of a short presentation

**Conditions**

None.

**Recommendations**

Engineering Mechanics; Advanced Mathematics; Introduction to Theory of Materials

**Learning Outcomes**

The student

- has the basic understanding of the materials theory and the classification of materials
- is able to independently generate numerical models using ABAQUS and can choose and apply adequate constitutive equations

**Content**

The course repeats the fundamentals of the theory of materials. It leads to the characterization and classification of material behavior as well as the specification by adequate material models. Here we focus on elastic, viscoelastic, plastic, and viscoplastic deformation behavior. Introducing the finite element program ABAQUS, the students learn how to analyze the material models numerically. Therefore ABAQUS-own and continuative constitutive equations are chosen.

**Literature**

Peter Haupt: Continuum Mechanics and Theory of Materials, Springer; ABAQUS Manual; Lecture notes

## Course: Fabrication Processes in Microsystem Technology [2143882]

**Coordinators:** K. Bade

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

### Learning Control / Examinations

Oral examination, 20 minutes

### Conditions

Bachelor mach., wing.

### Recommendations

Lectures

Mikrosystemtechnik I [2141861] and/or II [2142874]

### Learning Outcomes

The student

- collects advanced knowledge
- understands process conditions and process layout
- gains interdisciplinary knowledge (chemistry, manufacturing, physics)

### Content

The lecture offers an advanced understanding of manufacturing processes in microsystem technology. Basic aspects of microtechnological processing will be introduced. With examples from semiconductor microfabrication and microsystem technology the base processing steps for conditioning and finishing, patterning, removal are imparted. Nano-patterning is covered is also included and the micro-nano interface is discussed. By the help of typical processing steps elementary mechanisms, process execution, and equipment are explained. Additionally quality control, process control and environmental topics are included

### Media

pdf files of presentation sheets

### Literature

M. Madou

Fundamentals of Microfabrication

CRC Press, Boca Raton, 1997

W. Menz, J. Mohr, O. Paul

Mikrosystemtechnik für Ingenieure

Dritte Auflage, Wiley-VCH, Weinheim 2005

L.F. Thompson, C.G. Willson, A.J. Bowden

Introduction to Microlithography

2<sup>nd</sup> Edition, ACS, Washington DC, 1994

## Course: Solid State Reactions and Kinetics of Phase Transformations (with exercises) [2193003]

**Coordinators:** P. Franke, K. Krüger

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral examination (30 min)

### Conditions

- Basic course in materials science and engineering
- physical chemistry

### Recommendations

none

### Learning Outcomes

The students acquire knowledge about:

- diffusion mechanisms
- Fick's laws
- basic solutions of the diffusion equation
- evaluation of diffusion experiments
- interdiffusion processes
- the thermodynamic factor
- parabolic growth of layers
- formation of pearlite
- microstructural transformations according to the models of Avrami and Johnson-Mehl
- TTT diagrams

### Content

1. Crystal Defects and Mechanisms of Diffusion
2. Microscopic Description of Diffusion
3. Phenomenological Treatment
4. Diffusion Coefficients
5. Diffusion Problems; Analytical Solutions
6. Diffusion with Phase Transformation
7. Kinetics of Microstructural Transformations
8. Diffusion at Surfaces, Grain Boundaries and Dislocations

### Literature

1. J. Crank, „The Mathematics of Diffusion“, 2nd Ed., Clarendon Press, Oxford, 1975.
2. J. Philibert, „Atom Movements“, Les Éditions de Physique, Les Ulis, 1991.
3. D.A. Porter, K.E. Easterling, M.Y. Sherif, „Phase Transformations in Metals and Alloys“, 3rd edition, CRS Press, 2009.
4. H. Mehrer, „Diffusion in Solids“, Springer, Berlin, 2007.

## Course: Finite Volume Methods for Fluid Flow [2154431]

**Coordinators:** C. Günther

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral

Duration: 30 minutes

no auxiliary means

### Conditions

None.

### Recommendations

Fundamental Knowledge about Fluid Mechanics

### Learning Outcomes

Students can describe all fundamental aspects of the finite volume methods, which form the basis for a number of different commercial CFD codes.

### Content

The Finite Volume Method (=FVM) is nowadays of great interest, as it guarantees conservation of all relevant variables and as it can be used on nearly arbitrary meshes. By this it is a fundamental tool for numerical simulation of flows, which plays an ever growing role for construction and engineering and is the basis of several commercial or research codes as CFX, STAR-CCM+, FLUENT or OpenFOAM. The lecture is concerned with all aspects of FVM, mesh generation is also included. Newer developments as CVFEM (control volume based FEM) are described.

- Introduction
- Conservative schemes
- Finite volume method
- Analysis of FVM
- CVFEM as conservative FEM
- FVM for Navier-Stokes Equations
- Basics of mesh generation

### Remarks

The lecture is recommended for students of mechanical, chemical or electrical engineering and is also of interest for people which are interested in FVM in a context other than fluid flow problems.

**Course: Fluid-Structure-Interaction [2154401]****Coordinators:** M. Mühlhausen**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral exam

Duration: 30 min

no auxiliary means

**Conditions**

none

**Recommendations**

Basic Knowledge about Fluid Mechanics

**Learning Outcomes**

The students are familiar with the numerical treatment of coupled problems. After completing this course students are able to describe a fluid-structure coupled problem and to derive its numerical formulation. They are familiar with the different coupling possibilities between the two regions and the corresponding advantages and disadvantages. Finally, the students are aware of the fact that not every result of a numerical simulation necessarily reflects reality and can thus critically judge the numerically obtained results.

**Content**

The lecture first introduces/recalls the fundamental governing equations that describe fluids and structures. After the characterization of the problem, the relevant equations are discussed and geometry and grid generation are treated. The resulting partial differential equations are transformed into an algebraic set of equations using different DFG and CSD methods and discretization schemes. Different methods for fluid structure coupling are introduced, where the resulting stability problem is treated in detail. Finally, the obtained result is critically examined in terms of errors and inaccuracy and verification and validation procedures are introduced.

The lecture includes an introduction to function of CFG-Programs and Matlab routines that are related to the theoretically discussed approaches.

**Literature**

will be introduced during the lecture

**Remarks**

Block course with limited number of participants, registration in the secretary's office required.

See details at [www.istm.kit.edu](http://www.istm.kit.edu)

## Course: Fluid Technology [2114093]

**Coordinators:** M. Geimer, M. Scherer

**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 4              | Winter term | de                   |

### Learning Control / Examinations

The assessment consists of a written exam (2 hours) taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

### Conditions

None.

### Learning Outcomes

The students will be able to

- know and understand physical principles of fluid power systems
- know the current components and their operating mode
- know the advantages and disadvantages of different components
- dimension the components for a given purpose
- calculate simple systems

### Content

In the range of hydrostatics the following topics will be introduced:

- Hydraulic fluids
- Pumps and motors
- Valves
- Accessories
- Hydraulic circuits.

In the range of pneumatics the following topics will be introduced:

- Compressors
- Motors
- Valves
- Pneumatic circuits.

### Literature

Scritum for the lecture *Fluidtechnik*  
Institute of Vehicle System Technology  
downloadable

**Course: Fundamentals of Combustion I [3165016]****Coordinators:** U. Maas, A. Goldman**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

**Learning Control / Examinations**

The examination results from the chosen module, otherwise:

Written exam

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

After completing this course students are able to:

- explain the chemical and physical processes governing combustion.
- discuss diagnostic methods applied in combustion science.
- describe laminar and turbulent flames in a mathematical way.
- analyse the working principle of various technical combustion systems (e. g. piston engines, gas turbines, furnaces).

**Content**

Fundamental concepts and phenomena

Experimental analysis of flames

Conservation equations for laminar flat flames

Thermodynamics of combustion processes

Transport phenomena

Chemical reactions

Chemical kinetics mechanisms

Laminar premixed flames

Laminar diffusion flames

**Media**

Blackboard and Powerpoint presentation

**Literature**

Lecture notes,

Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation, authors: U. Maas, J. Warnatz, R.W. Dibble, Springer-Lehrbuch, Heidelberg 1996

**Remarks**

Lecture number of the tutorial for this class is 3165017

**Course: Functional Ceramics [2126784]****Coordinators:** M. Hoffmann, M. Bäurer**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (20 min) taking place at the agreed date.

Auxiliary means: none

The re-examination is offered upon agreement.

**Conditions**

none

**Recommendations**

Basics of the course "Introduction to Ceramics" should be known.

**Learning Outcomes**

The students know the correlation among crystal structure, defect chemistry and electrical, dielectric and piezoelectric properties and are familiar with the different methods for powder preparation, shaping and sintering. They know the functionality and application fields of semiconducting, piezoelectric and pyroelectric ceramics.

**Content**

The course gives an introduction to physics and chemistry of functional ceramics, provides an overview of the corresponding processing methods and highlights the properties and application of the most relevant materials.

It is arranged in the following units:

- Crystal structures and defect chemistry
- Thermodynamic of interfaces and grain boundaries
- Methods for the preparation of functional ceramics
- Dielectric materials and insulators
- Semiconducting ceramics (varistors, PTC- und NTC-ceramics)
- Ion conductive ceramics (oxygen sensors, solid oxid fuel cells)
- Piezoelectric ceramics
- Pyroelectric ceramics
- Elektrooptical ceramics

**Media**

Slides for the lecture:

available under <http://www.iam.kit.edu/km/289.php>

**Literature**

Y.-M. Chiang, D. Birnie III and W.D. Kingery, "Physical Ceramics", Wiley (1997)

A.J. Moulson, J.M. Herbert, "Electroceramics, Materials - Properties - Applications", Chapman and Hall (1990)

Y. Xu, "Ferroelectric Materials and Their Applications", Elsevier (1991)

H. Jaffe, W.R. Cook and H. Jaffe, "Piezoelectric Ceramics", Academic Press (1971)

**Remarks**

The course will not take place every year

**Course: Fusion Technology A [2169483]****Coordinators:** R. Stieglitz**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral: Acceptance for the oral test only by certification of attendance of exercises

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

Basic knowledge in fluid mechanics, material sciences and physics

**Recommendations**

appreciated is knowledge in heat and mass transfer as well as in electrical engineering

**Learning Outcomes**

The lecture describes the functional principle of a fusion reactor, starting from the plasma, the magnets, the tritium and fuel cycle, the vacuum technology and the associated material sciences. The physical principles are discussed and scaling laws are formulated. One major emphasis is directed towards the interface between the individual fields of disciplines which to a large extent determines the technological scaling of a fusion facility. Here methods are communicated, which allow for an identification of central parameters and a corresponding technical analysis. Based on the elaborated acquisition skills approaches to design solution strategies are transmitted. Also technical solutions are shown and the weaknesses are discussed and evaluated.

**Content**

Actual energy situation and perspectives. Transfer of the fundamentals in structure of matter physics, fusion and nuclear fission, plasma. Ignition conditions of a plasma, plasma instabilities, control of a plasma and transport in plasmas. Magnet technology, super-conductivity, materials in super-conductivity, fabrication and design of magnets, tritium and fuel cycle, vacuum technology in fusion. The individual sections describe additionally the task, the challenges and the design of state of the art technology. Also an introduction into design criteria and materials for fusion are given, which scopes the fundamentals of material science, characterization of fusion materials, material damage by irradiation and calculation methods for nuclear materials. Additionally hints for an adequate material selection are presented.

**Literature**

Within each subblock an adequate selection of literature is given. Additionally the students get the lecture materials in printed and electronic version.

**Course: Fusion Technology B [2190492]****Coordinators:** R. Stieglitz**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Completed set of practical courses within lecture

Duration: approximately 25 minutes

no tools or reference materials may be used during the exam

**Conditions**

reliable capability to use fundamental knowledge communicated in the bachelor study in physics, heat. and mass transfer and engineering design

**Recommendations**

attendance of fusion technology A lecture

**Learning Outcomes**

The lecture comprising two semesters is addressing students of engineering science and physics after a successful intermediate diploma. It intends to give an introduction to current fusion research and development and to the long term target of fusion as a promising energy source. After a short insight into fusion physics the lecture concentrates on key technologies for future fusion reactors. The lectures are complemented by exercises at different institutes located at the campus north (two to three afternoons per subject).

**Content**

Die Fusionstechnologie B beinhaltet

Fusion neutronics, plasma facing components and plasma heating-and current drive methods. The section fusion neutronics scopes the fundamentals and calculation methods, which allows for a physical design of a nuclear fusion reactor and the corresponding components (such as blankets, divertors, shielding, activation and dose rate). Fusion reactors produce fuel their "self". The necessary blankets are complex structures whose foundations and concept options, design criteria and methods are discussed. Also the divertor is a plasma facing component. Its tasks, constraints, and design concepts are explained. The arrangement of the plasma facing components in a fusion power plant means changing demands on the system integration and energy conversion. To ignite the plasma extreme temperatures of several million degrees are required. For this purpose, special plasma heating techniques are used such as electron cyclotron resonance heating (ECRH), ion-cyclotron resonance heating (ICRH), the current drive at the lower hybrid frequency, and the neutral particle injection. Their basic mode of action, the design criteria, the transmission options and performance are presented and discussed. Additionally the heating method used also for plasma stabilization. Here are some considerations and limitations are presented.

**Literature**

Lecture notes

McCracken, Peter Scott, Fusion, The Energy of Universe, Elsevier Academic Press, ISBN: 0-12-481851-X

## Course: Combined Cycle Power Plants [2170490]

**Coordinators:** T. Schulenberg

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

Oral Examination 30 min

### Conditions

Knowledge in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.

### Recommendations

We recommend to combine the lecture with the Simulator Exercises for Combined Cycle Power Plants (2710491)

### Learning Outcomes

The students know the design and operation principles of major components of advanced combined cycle power plants including their control, as well as the dynamic response of combined cycle power plants to grid requirements.

### Content

Layout of a combined cycle power plant, design and operation of gas turbines, of the heat recovery steam generator, of the feedwater system and cooling systems. Design and operation of steam turbines, of the generator and its electrical systems. System response to challenging grids, protection systems, water make-up and water chemistry. Design concepts of different power plant manufacturers, innovative power plant concepts.

### Media

Lecture with English Power Point Presentation

### Literature

Power point slides and other lecture material will be provided.

Recommended additional literature:

C. Lechner, J. Seume, Stationäre Gasturbinen, Springer Verlag, 2. Auflage 2010

**Course: [2154200]****Coordinators:** F. Magagnato**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 min

no auxiliary means

**Conditions**

none

**Recommendations**

basic skills in mathematics, physics and fluid dynamics

**Learning Outcomes**

The students can describe the governing equations of Gas Dynamics in integral form und the associated basics in Thermodynamics. They can calculate compressible flows analytically. The students are familiar with the Rankine-Hugoniot curve and the Rayleigh line and can name those. They can derive the continuity-, the momentum- and the energy equations in differential form. With the help of the stationary flow filament theory they can calculate the normal shock wave and the associated increase of entropy.

They are able to determine the stagnation values of the gas dynamic variables and to determine their critical values. The students can apply the flow filament theory for variable cross-sectional areas and can distinguish the related different flow states inside the Laval nozzle.

**Content**

This lecture covers the following topics:

- Introduction, basics of Thermodynamics
- Governing equations of gas dynamics
- Application of the conservation equations
- The transport equations in differential form
- Stationary flow filament theory with and without shock waves
- Discussion of the energy equation: Stagnation and critical values
- Flow filament theory for variable cross-sectional areas. Flow inside a Laval nozzle

**Literature**

John, J., and Keith T. Gas Dynamics. 3rd ed.

Harlow: Prentice Hall, 2006

Rathakrishnan, E. *Gas Dynamics*. Prentice Hall of India Pvt. Ltd, 2006

**Course: Gas Engines [2134141]****Coordinators:** R. Golloch**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

**Learning Control / Examinations**

Oral examination, duration 25 min., no auxiliary means

**Conditions**

none

**Recommendations**

Knowledge about „Verbrennungsmotoren A und B“ or “Fundamentals of Combustion Engines I and II”

**Learning Outcomes**

The student can name and explain the function, characteristics and application areas of gas and dual fuel engines. He is able to distinguish from engines using liquid fuels. The student describe and explain gaseous fuels, engine subsystems, combustion processes and exhaust gas aftertreatment technologies. He is capable to analyse and evaluate current development areas and technical challenges.

**Content**

Based on the basics of internal combustion engines the students learn about functions of modern gas and dual fuel engines. Core learning areas are gaseous fuels, combustion processes including abnormal combustion characteristics, subsystems like gas admission, ignition, safety and control systems. Further knowledge will be taught on emissions, exhaust gas aftertreatment, applications and operation characteristics.

**Media**

Lecture with PowerPoint slides

**Literature**

Lecture Script, prepared by the lecturer. Obtainable at the Institut für Kolbenmaschinen

Recommended:

- Merker, Schwarz, Teichmann: Grundlagen Verbrennungsmotoren, Vieweg + Teubner Verlag 2011;
- Zacharias: Gasmotoren, Vogel Fachbuch 2001

**Course: Global vehicle evaluation within virtual road test [2114850]****Coordinators:** B. Schick**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: CarMaker Simulation Environment

**Conditions**

none

**Learning Outcomes**

The students have an overview of the vehicle dynamics simulation, the model parametrization and the related data sources. They have good knowledge about vehicle dynamics test methods and related execution of virtual test driving (open loop, closed loop). They are able to evaluate driving behavior based on self-created results. They have achieved knowledge about influences and interactions of components such as tires, suspension, kinematics and compliance, roll bars, steering, brakes, mass distribution and powertrain and they have the qualification to analyze, to judge and to optimize components with regard to global vehicle behavior.

**Content**

1. Testing and evaluation methods
2. Fundamentals of vehicle dynamics simulation
3. Execution of virtual test driving and evaluation of the results
4. Influence of several components and optimization of global driving behavior

**Literature**

1. Reimpell, J.: Fahrwerktechnik: Grundlagen, Vogel Verlag, 1995
2. Unrau, H.-J.: Skriptum zur Vorlesung "Fahreigenschaften I"
3. Unrau, H.-J.: Skriptum zur Vorlesung "Fahreigenschaften II"
4. IPG: User Guide CarMaker

**Course: Foundry Technology [2174575]****Coordinators:** C. Wilhelm**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

duration: 20 - 30 minutes

no notes

**Conditions**

Required: WK 1+2

**Learning Outcomes**

The students know the specific moulding and casting techniques and are able to describe them in detail. The students know the application of moulding and casting techniques concerning castings and metals, their advantages and disadvantages in comparison, their application limits and are able to describe these in detail.

The students know the applied metals and are able to describe advantages and disadvantages as well as the specific range of use.

The students are able, to describe detailed mould and core materials, technologies, their application focus and mould-affected casting defects.

The students know the basics of casting process of any casting parts concerning the above mentioned criteria and are able to describe detailed.

**Content**

Moulding and casting processes

Solidifying of melts

Castability

Fe-Alloys

Non-Fe-Alloys

Moulding and additive materials

Core production

Sand reclamation

Feeding technology

Design in casting technology

Casting simulation

Foundry Processes

**Literature**

Reference to literature, documentation and partial lecture notes given in lecture

## Course: Global Production and Logistics - Part 1: Global Production [2149610]

**Coordinators:** G. Lanza

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The assessment is carried out as an oral exam. The examination date can be defined individually.

### Conditions

None

### Recommendations

Combination with Global Production and Logistics – Part 2

### Learning Outcomes

The students . . .

- can explain the general conditions and influencing factors of global production.
- are capable to apply defined procedures for site selection and to evaluate site decisions with the help of different methods.
- are able to select the adequate scope of design for site-appropriate production and product construction case-specifically.
- can state the central elements in the planning process of establishing a new production site.
- are capable to make use of the methods to design and scale global production networks for company-individual problems.
- are able to show up the challenges and potentials of the departments sales, procurement as well as research and development on global basis.

### Content

Target of the lecture is to depict the challenges and fields of action of global operating companies and to give an overview of central aspects in global production networks as well as establishing a deepening knowledge of established methods and procedures for design and scale. Within the course methods for site selection, procedures for site specific adjustment of product construction and product technology as well as planning approaches to establish a new production site are imparted. The course is rounded off by showing the characteristics of the departments sale, procurement as well as research and development under global aspects.

The topics are:

- Basic conditions and influencing factors of global production (historical development, targets, chances and threats)
- Global sales
- Site selection
- Site specific production adjustment
- Establishing of new production sites
- Global procurement
- Design and management of global production networks
- Global research and development

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

recommended secondary literature:

Abele, E. et al: Global Production – A Handbook for Strategy and Implementation, Springer 2008 (english)

**Remarks**

None

## Course: Global Production and Logistics - Part 2: Global Logistics [2149600]

**Coordinators:** K. Furmans

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral / written (if necessary) => (see "Studienplan Maschinenbau", current version)

### Conditions

none

### Recommendations

We recommend the course "Logistics - organisation, design and control of logistic systems " (2118078) beforehand.

### Learning Outcomes

Students are able to:

- assign basic problems of planning and operation of global supply chains and plan them with appropriate methods,
- describe requirements and characteristics of global trade and transport, and
- evaluate characteristics of the design from logistic chains regarding their suitability.

### Content

Characteristics of global trade

- Incoterms
- Customs clearance, documents and export control

Global transport and shipping

- Maritime transport, esp. container handling
- Air transport

Modeling of supply chains

- SCOR model
- Value stream analysis

Location planning in cross-border-networks

- Application of the Warehouse Location Problem
- Transport Planning

Inventory Management in global supply chains

- Stock keeping policies

Inventory management considering lead time and shipping costs

### Media

presentations, black board

### Literature

#### Elective literature:

- Arnold/Isermann/Kuhn/Tempelmeier. HandbuchLogistik, Springer Verlag, 2002 (Neuaufgabe in Arbeit)

- Domschke. Logistik, Rundreisen und Touren, Oldenbourg Verlag, 1982
- Domschke/Drexl. Logistik, Standorte, Oldenbourg Verlag, 1996
- Gudehus. Logistik, Springer Verlag, 2007
- Neumann-Morlock. Operations-Research, Hanser-Verlag, 1993
- Tempelmeier. Bestandsmanagement in Supply Chains, Books on Demand 2006
- Schönsleben. Integrales Logistikmanagement, Springer, 1998

**Remarks**

none

## Course: Size effects in micro and nanostructures materials [2181744]

**Coordinators:** P. Gumbsch, D. Weygand, P. Gruber, M. Dienwiebel

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

compulsory preconditions: none

### Recommendations

preliminary knowlegde in materials science

### Learning Outcomes

The student can

- describe the mechanical behavior of nano and micrometer sized structured materials and analyse and explain the origin for the differences compared to classical materials behavior.
- explain processing routes, experimetal characterization methods and adequate modelling schems for nano- and microstructred maetrialis.

### Content

Modern topics in the mechanics of materials are presented.

1. Nanotubes
  - \* production routes, properties
  - \* application
2. cermics
  - \* defect statistics
3. size effect in metallic structures
  - \* thin film mechanics
  - \* micro pillar
  - \* modelling: discrete dislocation dynamic
4. nanocontact:
  - \* gecko
  - \* hierachical structures
5. nanotribology
  - \* contact, friction: simple and multiple contacts
  - \* radio nucleid technique

### Literature

lecture slides

## Course: Fundamentals of Energy Technology [2130927]

**Coordinators:** A. Badea

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 5              | Summer term | de                   |

### Learning Control / Examinations

#### Conditions

none

#### Learning Outcomes

The students will receive state of the art knowledge about the very challenging field of energy industry and the permanent competition between the economical profitability and the long-term sustainability.

#### Content

The following relevant fields of the energy industry are covered:

- Energy forms
- Thermodynamics relevant to energy industry
- Energy sources: fossil fuels, nuclear energy, renewable sources
- Energy industry in Germany, Europe and worldwide
- Power generation and environment
- Evaluation of energy conversion processes
- Thermal/electrical power plants and processes
- Transport of energy / energy carriers
- Energy storage
- Systems utilizing renewable energy sources
- Basics of economic efficiency and calculus / Optimisation
- Future of the energy industry

## Course: Automotive Engineering I [2113805]

**Coordinators:** F. Gauterin, H. Unrau

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term | de                   |

### Learning Control / Examinations

Written examination

Duration: 120 minutes

Auxiliary means: none

### Conditions

Can not be combined with lecture [2113809]

### Recommendations

None.

### Learning Outcomes

The students know the movements and the forces at the vehicle and are familiar with active and passive security. They have proper knowledge about operation of engines and alternative drives, the necessary transmission between engine and drive wheels and the power distribution. They have an overview of the components necessary for the drive and have the basic knowledge, to analyze, to judge and to develop the complex system "vehicle".

### Content

1. History and future of the automobile
2. Driving mechanics: driving resistances and driving performances, mechanics of the longitudinal and transverse forces, collision mechanics
3. Engines: combustion engine, alternative drives (e.g. electric motor, fuel cell)
4. Transmission: clutches (e.g. friction clutch, visco clutch), transmission (e.g. mechanical transmission, hydraulic fluid transmission)
5. Power transmission and distribution: drive shafts, cardon joints, differentials

### Literature

1. Mitschke, M./ Wallentowitz, H.: Dynamik der Kraftfahrzeuge, Springer-Verlag, Berlin, 2004
2. Braes, H.-H.; Seiffert, U.: Handbuch Kraftfahrzeugtechnik, Vieweg&Sohn Verlag, 2005
3. Gnadler, R.: Script to the lecture 'Automotive Engineering I'

**Course: Automotive Engineering II [2114835]****Coordinators:** F. Gauterin, H. Unrau**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Written Examination

Duration: 90 minutes

Auxiliary means: none

**Conditions**

Can not be combined with lecture [2114855]

**Recommendations**

None.

**Learning Outcomes**

The students have an overview of the modules, which are necessary for the road holding of a motor vehicle and the power transmission between vehicle bodywork and roadway. They have knowledge of different wheel suspensions, the tyres, the steering elements and the brakes. They know different execution forms, the function and the influence on the driving or brake behavior. They are able to develop the appropriate components correctly. They are ready to analyze, to judge and to optimize the complex relationship of the different components under consideration of boundary conditions.

**Content**

1. Chassis: Wheel suspensions (rear axles, front axles, kinematics of axles), tyres, springs, damping devices
2. Steering elements: Steering elements of single vehicles and of trailers
3. Brakes: Disc brake, drum brake, retarder, comparison of the designs

**Literature**

1. Heißing, B./Ersoy, M.: Fahrwerkhandbuch: Grundlagen, Fahrdynamik, Komponenten, Systeme, Mechatronik, Perspektiven, Vieweg-Verlag, Wiesbaden, 2011
2. Breuer, B./Bill, K.-H.: Bremsenhandbuch: Grundlagen - Komponenten - Systeme - Fahrdynamik, Vieweg-Verlag, Wiesbaden, 2012
3. Gnadler, R.: Script to the lecture 'Automotive Engineering II'

## Course: Grundlagen der Herstellungsverfahren der Keramik und Pulvermetallurgie [2193010]

**Coordinators:** R. Oberacker

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The assessment consists of an oral exam (20-30 min) taking place at the agreed date. The re-examination is offered upon agreement.

### Conditions

None.

### Recommendations

Knowledge of basic material science is assumed

### Learning Outcomes

The students know the basics of characterization of powders, pastes and suspensions. They have a fundamental understanding of the process technology for shaping of particulate systems. They are able to use these fundamentals to design selected wet- and dry forming processes.

### Content

The course covers fundamentals of the process technology for shaping of ceramic or metal particle systems. Important shaping methods are reviewed. The focus is on characterization and properties of particulate systems, and, in particular, on process technology for shaping of powders, pastes, and suspensions.

### Literature

- R.J. Brook: Processing of Ceramics I+II, VCH Weinheim, 1996
- M.N. Rahaman: Ceramic Processing and Sintering, 2nd Ed., Marcel Dekker, 2003
- W. Schatt ; K.-P. Wieters ; B. Kieback. „Pulvermetallurgie: Technologien und Werkstoffe“, Springer, 2007
- R.M. German. “Powder metallurgy and particulate materials processing. Metal Powder Industries Federation, 2005
- F. Thümmeler, R. Oberacker. “Introduction to Powder Metallurgy”, Institute of Materials, 1993

**Course: Fundamentals of catalytic exhaust gas aftertreatment [2134138]****Coordinators:** E. Lox**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination, Duration: 25 min., no auxiliary means

**Conditions**

none

**Recommendations**

Fundamentals of Combustion engines I helpful

**Learning Outcomes**

The students can name and explain the scientific fundamentals of the catalytic exhaust gas aftertreatment, as well as the technical, political and economical parameters of its application in engines for passenger cars and HD vehicles.

The students are able to point out and explain which emissions are formed in combustion engines, why these emissions are health-related critical and which measures the legislator has established to reduce the emissions.

**Content**

1. kind and source of emissions
2. emission legislation
3. principal of catalytic exhaust gas aftertreatment (EGA)
4. EGA at stoichiometric gasoline engines
5. EGA at gasoline engines with lean mixtures
6. EGA at diesel engines
7. economical basic conditions for catalytic EGA

**Literature**

Lecture notes available in the lectures

1. "Environmental Catalysis" Edited by G.Ertl, H. Knötzinger, J. Weitkamp Wiley-VCH Verlag GmbH, Weinheim, 1999 ISBN 3-527-29827-4
2. "Cleaner Cars- the history and technology of emission control since the 1960s" J. R. Mondt Society of Automotive Engineers, Inc., USA, 2000 Publication R-226, ISBN 0-7680-0222-2
3. "Catalytic Air Pollution Control - commercial technology" R. M. Heck, R. J. Farrauto John Wiley & Sons, Inc., USA, 1995 ISBN 0-471-28614-1
4. "Automobiles and Pollution" P. Degobert Editions Technic, Paris, 1995 ISBN 2-7108-0676-2
5. "Reduced Emissions and Fuel Consumption in Automobile Engines" F. Schaefer, R. van Basshuysen, Springer Verlag Wien New York, 1995 ISBN 3-211-82718-8
6. "Autoabgaskatalysatoren : Grundlagen - Herstellung - Entwicklung - Recycling - Ökologie" Ch. Hagelüken und 11 Mitautoren, Expert Verlag, Renningen, 2001 ISBN 3-8169-1932-4

## Course: Principles of Medicine for Engineers [2105992]

**Coordinators:** C. Pylatiuk

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral, also possible as an optional or part of a major subject

### Conditions

None.

### Recommendations

Organ support systems

### Learning Outcomes

Students have fundamental knowledge about functionality and anatomy of organs within different medical disciplines. The students further know about technical methods in diagnosis and therapy, common diseases, their relevance and costs. Finally the students are able to communicate with medical doctors in a way, in which they prevent misunderstandings and achieve a more realistic idea of each others expectations.

### Content

- Introduction: Definitions of "health" and "disease". History of medicine and paradigm shift towards evidence based medicine and personalized medicine.
- Special topics: nervous system, saltatory conduction, musculoskeletal system, cardio-circulatory system, narcosis, pain, respiratory system, sensory organs, gynaecology, digestive organs, surgery, nephrology, orthopaedics, immune system, genetics.

### Literature

- Adolf Faller, Michael Schünke: Der Körper des Menschen. Thieme Verlag.
- Renate Huch, Klaus D. Jürgens: Mensch Körper Krankheit. Elsevier Verlag.

## Course: Introduction to Microsystem Technology I [2141861]

**Coordinators:** A. Guber

**Part of the modules:** Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

#### Conditions

None.

#### Learning Outcomes

The lecture gives an introduction into the basics of microsystems technology. In analogy to processes employed in fabrication of microelectronics circuits the core technologies as well as materials for producing microstructures and components are presented. Finally, various techniques for Silicon micromachining are explained and illustrated with examples for micro-components and micro-systems.

#### Content

- Introduction in Nano- and Microtechnologies
- Silicon and processes for fabricating microelectronics circuits
- Basic physics background and crystal structure
- Materials for micromachining
- Processing technologies for microfabrication
- Silicon micromachining
- Examples

#### Literature

M. Madou  
 Fundamentals of Microfabrication  
 Taylor & Francis Ltd.; Auflage: 3. Auflage. 2011

## Course: Introduction to Microsystem Technology II [2142874]

**Coordinators:** A. Guber

**Part of the modules:** Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

#### Conditions

None.

#### Learning Outcomes

The lecture gives an introduction into the basics of microsystems technology. In the first part, methods for lithographic pattern transfer are summarized. Then specific techniques such as the LIGA process, micro-machining, and laser-patterning are explained and examples are given. Finally assembly and packaging methods are presented leading into a discussion of entire microsystems.

#### Content

- Introduction in Nano- and Microtechnologies
- Lithography
- LIGA-technique
- Mechanical microfabrication
- Patterning with lasers
- Assembly and packaging
- Microsystems

#### Literature

M. Madou  
 Fundamentals of Microfabrication  
 Taylor & Francis Ltd.; Auflage: 3. Auflage. 2011

## Course: Foundations of nonlinear continuum mechanics [2181720]

**Coordinators:** M. Kamlah

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

Engineering Mechanics - Advanced Mathematics

### Learning Outcomes

The students understand the fundamental structure of a continuum theory consisting of kinematics, balance laws and constitutive model. In particular, they recognize non-linear continuum mechanics as a common structure including all continuum theories of thermomechanics, which are obtained by adding a corresponding constitutive model. The students understand in detail the kinematics of finite deformation and know the transition to the geometrically linear theory they are familiar with. The students know the spatial and material representation of the theory and the different related tensors. The students take the balance laws as physical postulates and understand their respective physical motivation.

### Content

The lecture is organized in three parts. In the first part, the mathematical foundations of tensor algebra and tensor analysis are introduced, usually in cartesian representation. In the second part of the lecture, the kinematics, i.e. the geometry of deformation is presented. Besides finite deformation, geometric linearization is discussed. The third part of the lecture deals with the physical balance laws of thermomechanics. It is shown, how a special classical theory of continuum mechanics can be derived by adding a corresponding constitutive model. For the illustration of the theory, elementary examples are discussed repeatedly.

### Literature

lecture notes

## Course: Fundamentals of reactor safety for the operation and dismantling of nuclear power plants [2190465]

**Coordinators:** V. Sánchez-Espinoza

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

### Learning Control / Examinations

**oral examination;** duration: 20-30 minutes

### Conditions

Nuclear Safety I: Fundamentals, Nuclear power plants, Nuclear thermal hydraulics

### Recommendations

none

### Learning Outcomes

- gain understanding for safety analysis and its methods
- get familiar with the mathematical-physical basis of numerical safety analysis codes used for the safety demonstration as well as with the role of code validation
- get familiar with the methodology to analyse design basis accidents of Light Water Reactors and with the step-by-step of the modelling of nuclear power plants with simulation tools

### Content

The goal of this lecture is to impart the main elements and newest methods applied in the industry and by regulators that are needed to perform a safety assessment of nuclear power plants of generation 2 and 3 using numerical simulation tools. This lecture is focused on the deterministic safety analysis methodology; the mathematical and physical bases of numerical simulation tools used for safety demonstration and last but not least the safety criteria. The methodology and the prediction capability of Safety Analysis Tools (TRACE/PARCS, RELAP5/PARCS) widely used in industry, regulators and R&D institutions is exemplary demonstrated by analyzing selected transients and accidents of Light Water Reactors (LWR). The examples will describe the practical steps developing integral nuclear power plant models for the analysis of the normal and off-normal operation conditions. This lecture will be concentrated on the following topics:

- Safety analysis- an introduction
- Mathematical-physical basis of coupled neutronic-thermal hydraulic Best-Estimate codes
- Characterization of the plant conditions (start-up, operation, shutdown)
- Design basis accidents
- Methodologies for the accident analysis of Pressurized and Boiling Water Reactors (PWR, BWR)
- Analysis of selected transients and accidents of PWR and BWR (RIA, LOCA, MSLB, TUSA)
- Beyond design basis accidents (physical phenomena and simulation tools)

**Course: Fundamentals of X-ray Optics I [2141007]****Coordinators:** A. Last**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

**Conditions**

basics in optics

**Recommendations**

This lecture addresses to students in mechanical engineering and physics interested in X-ray optics.

additional lecture: accelerator physics I/II (2208111)

<http://www.imt.kit.edu/113.php>**Learning Outcomes**

The lecture will enable the students to judge capabilities of different X-ray optical imaging methods and instrumentation and to select suitable methods for a given task.

**Content**

The lecture covers general principles of optics as well as basics, functioning and application of reflective, refractive and diffractive X-ray optical elements and systems. Selected X-ray analytical imaging methods and the necessary optical elements are discussed including their potentials and limitations.

**Literature**

M. Born und E. Wolf

Principles of Optics, 7th (expanded) edition

Cambridge University Press, 2010

A. Erko, M. Idir, T. Krist und A. G. Michette

Modern Developments in X-Ray and Neutron Optics

Springer Series in Optical Sciences, Vol. 137

Springer-Verlag Berlin Heidelberg, 2008

D. Attwood

Soft X-Rays and Extreme Ultraviolet Radiation: Principles and Applications

Cambridge University Press, 1999

**Remarks**

Lecture dates will be fixed in agreement with the students, see institutes website.

A visit at synchrotron ANKA is possible if requested.

## Course: Basics of Technical Logistics [2117095]

**Coordinators:** M. Mittwollen, Madzharov

**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

### Learning Control / Examinations

after each lesson period; oral / written (if necessary) => (look at "Studienplan Maschinenbau", latest version)

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

Students are able to:

- Describe processes and machines of technical logistics,
- Model the fundamental structures and the impacts of material handling machines with mathematical models,
- Refer to industrially used machines and
- Model real machines applying knowledge from lessons and calculate their dimensions.

### Content

Bases effect model of conveyor machines made for the change of position and orientation; conveyor processes; identification systems; drives; mechanical behaviour of conveyors; structure and function of conveyor machines; elements of intralogistics  
sample applications and calculations in addition to the lectures inside practical lectures

### Media

supplementary sheets, projector, blackboard

### Literature

Recommendations during lessons

**Course: Fundamentals of Combustion I [2165515]****Coordinators:** U. Maas**Part of the modules:** Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**Compulsory elective subject: Written exam.  
In SP 45: oral exam.**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

After completing this course students are able to:

- explain the chemical and physical processes governing combustion.
- discuss diagnostic methods applied in combustion science.
- describe laminar and turbulent flames in a mathematical way.
- analyse the working principle of various technical combustion systems (e. g. piston engines, gas turbines, furnaces).

**Content**

Fundamental concepts and phenomena  
 Experimental analysis of flames  
 Conservation equations for laminar flat flames  
 Thermodynamics of combustion processes  
 Transport phenomena  
 Chemical reactions  
 Chemical kinetics mechanisms  
 Laminar premixed flames  
 Laminar diffusion flames

**Media**

Blackboard and Powerpoint presentation

**Literature**

Lecture notes,  
 Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation,  
 authors: U. Maas, J. Warnatz, R.W. Dibble, Springer-Lehrbuch, Heidelberg 1996

**Remarks**

Compulsory elective subject: 2+1 SWS and 5 LP.

**Course: Fundamentals of combustion II [2166538]****Coordinators:** U. Maas**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

After completing the course attendents are able to:

- explain the processes involved in ignition (auto-ignition and induced ignition).
- describe the governing mechanisms in combustion of liquid and solid fuels.
- understand the mechanisms governing pollutant formation.
- describe turbulent reacting flows by means of simple models.
- explain the occurrence of engine knock.
- outline the basic numerical schemes applied in the simulation of reacting flows.

**Content**

Ignition processes

Three dimensional Navier-Stokes equations for reacting flows

Tubulent reactive flows

Turbulent non-premixed flames

Turbulent premixed flames

Combustion of liquid and solid fuels

Engine knock

NOx formation

Formation of hydrocarbons and soot

**Media**

Blackboard and Powerpoint presentation

**Literature**

Lecture notes;

Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation;  
Authors: U. Maas, J. Warnatz, R.W. Dibble, Springer; Heidelberg, Karlsruhe, Berkley 2006

## Course: Fundamentals of Combustion Engines I [2133103]

**Coordinators:** H. Kubach, T. Koch

**Part of the modules:** Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

### Learning Control / Examinations

oral examination, Duration: 25 min., no auxiliary means

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

The student can name and explain the working principle of combustion engines. He is able to analyse and evaluate the combustion process. He is able to evaluate influences of gas exchange, mixture formation, fuels and exhaust gas aftertreatment on the combustion performance. He can solve basic research problems in the field of engine development.

### Content

Introduction, History, Concepts  
 Working Principle and Thermodynamics  
 Characteristic Parameters  
 Air Path  
 Fuel Path  
 Energy Conversion  
 Fuels  
 Emissions  
 Exhaust Gas Aftertreatment

## Course: Fundamentals of Combustion Engines II [2134131]

**Coordinators:** H. Kubach, T. Koch

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

### Learning Control / Examinations

oral examination, duration: 25 minutes, no auxiliary means

### Conditions

None.

### Recommendations

Fundamentals of Combustion Engines I helpful

### Learning Outcomes

The students deepen and complement their knowledge from the lecture combustion engines A. they can name and explain construction elements, development tools and latest development trends. They are be able to analyse and evaluate powertrain concepts which are subject of the lecture.

### Content

Emissions

Fuels

Drive Train Dynamics

Engine Parts

Boosting

Alternative Powertrain Concepts

Special Engine Concepts

Power Transmission

**Course: Optical Flow Measurement: Fundamentals and Applications [2153410]****Coordinators:** F. Seiler**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

no auxiliary means

**Conditions**

none

**Learning Outcomes**

The students can thoroughly describe the introduced optical measurement techniques. From recently achieved results in shock tunnels, they are able to explain the working principle(s) of the most important registration and visualization methods working with either tracer scattering or with the information obtained with light passing directly through the measuring regime. Particularly, the students are qualified to comparatively discuss the measurement techniques for velocity, density and gas temperature (listed below) and can furthermore illustrate their working principles with examples:

- shadowgraph techniques
- Schlieren method
- Mach/Zehnder- and Differential interferometer
- Particle Image Velocimetry (PIV)
- Doppler Global Velocimetry (DGV)
- Doppler picture velocimetry (DPV)
- classical single-beam
- cross-beam anemometry
- interference velocimetry
- CARS-method
- laser-induced fluorescence (LIF)

**Content**

- Visualisations techniques
- Techniques for local point-wise measurement
- Techniques using light scattering methods
- Laser-induced fluorescence

**Literature**

H. Oertel sen., H. Oertel jun.: Optische Strömungsmeßtechnik, G. Braun, Karlsruhe

F. Seiler: Skript zur Vorlesung über Optische Strömungsmeßtechnik

**Course: Hardware/Software Codesign [23620]****Coordinators:** M. Hübner**Part of the modules:** Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral exam.

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

After completing the course, students can:

- understand the fundamentals of Hardware/Software Codesign.
- comprehend and classify target architectures.
- apply methods for the estimation of design quality.
- describe partitioning strategies for HW/SW systems.

**Content**

Hardware/Software Co-design is the denomination of the concurrent and interlocked design of a system's hardware and software components. The most modern embedded systems (for example mobile phones, automotive and industrial controller devices, game consoles, home cinema systems, network routers) are composed of cooperating hardware and software components. Enabled by the rapid progress in microelectronics, embedded systems are becoming increasingly more complex with manifold application specific criteria. The deployment of computer aided design tools is not only necessary for handling the increasing complexity, but also for reducing the design costs and time-to-market. The lecture Hardware/Software Codesign discusses the needed criteria & methods and possible hardware/software target architectures on following topics:

- Target architectures of HW/SW-systems
- DSP, microcontrollers, ASIPs, FPGAs, ASIC, System-on-Chip
- Processor design: Pipelining, superscalar, cache, VLIW
- Estimation of design quality
- Hardware- and software-performance
- Methods for hardware/software partitioning
- Iterative and constructive heuristics

Interface and communications synthesis

**Literature**Course material online: [estudium.fsz.kit.edu](http://estudium.fsz.kit.edu)

Literature: J. Teich, C. Haubelt: „Digitale Hardware/Software-Systeme-Synthese und Optimierung“, Springer-Verlag, 2007 (2. Auflage)

D.D. Gajski, F. Vahid, S. Narayan, J. Gong: „Specification and Design of Embedded Systems“, Prentice Hall, 1994

## Course: High Temperature Structural Materials [2174600]

**Coordinators:** M. Heilmaier

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral, 30min.

### Conditions

Relevant Bachelor degree

### Recommendations

None

### Learning Outcomes

Students are able to

- Define properly the term „high temperature“ with respect to materials
- Describe the shape of the creep curve based on underlying deformation mechanisms
- Rationalize the influence of relevant parameters such as temperature, stress, microstructure on the high temperature deformation behavior
- Develop strategies for improving creep resistance of alloys via modifying their composition
- Select properly industrially relevant high temperature structural materials for various applications

### Content

- Phenomenology of High Temperature Deformation
- Deformation Mechanisms
- High Temperature Structural Materials

### Literature

M.E. Kassner, Fundamentals of Creep in Metals and Alloys, Elsevier, Amsterdam, 2009

## Course: Human Biology [2106040]

**Coordinators:** C. Pylatiuk

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Preparation of a lesson

### Conditions

Mandatory attendance to the lecture

### Recommendations

Interest in functioning of the human body, interest in technology

### Learning Outcomes

#### Content

- Human biology in science and technology
- Sensory organs: anatomy, physiology and experiments
- Musculoskeletal system: anatomy, physiology and experiments
- Respiratory system: anatomy, physiology and experiments
- Digestive system: anatomy, physiology and experiments

## Course: Hydraulic Fluid Machinery I (Basics) [2157432]

**Coordinators:** M. Gabi

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term | de                   |

### Learning Control / Examinations

Oral or written examination (see announcement)

No tools or reference materials may be used during the exam.

### Conditions

2157432 (Hydraulic Machinery) can not be combined with the event 2157451 (Wind and Hydropower)

### Recommendations

2153412 Fluid mechanics

### Learning Outcomes

Students get to know the basics of hydraulic fluid machinery (pumps, fans, hydroturbines, windturbines, hydrodynamic transmissions) in general. Application of the knowledge in different fields of engineering.

The lecture introduces the basics of Hydraulic Fluid Machinery. The different types and shapes are presented. The basic equations for the preservation of mass, momentum and energy are discussed. Velocity schemes in typical cascades are shown, the Euler equation of fluid machinery and performance characteristics are deduced.

Similarities and dimensionless parameters are discussed. Fundamental aspects of operation and cavitation are shown.

Students are able to understand the working principle of Hydraulic Fluid Machinery as well as the interaction with typical systems, in which they are integrated.

### Content

1. Introduction
2. Basic equations
3. System analysis
4. Elementary Theory (Euler's equation of Fluid Machinery)
5. Operation and Performance Characteristics
6. Similarities, Specific Values
7. Control technics
8. Wind Turbines, Propellers
9. Cavitation
10. Hydrodynamic transmissions and converters

### Literature

1. Fister, W.: Fluidenergiemaschinen I & II, Springer-Verlag
2. Bohl, W.: Strömungsmaschinen I & II . Vogel-Verlag
3. Gülich, J.F.: Kreiselpumpen, Springer-Verlag
4. Pfeleiderer, C.: Die Kreiselpumpen. Springer-Verlag
5. Carolus, T.: Ventilatoren. Teubner-Verlag
6. Kreiselpumpenlexikon. KSB Aktiengesellschaft
7. Zierrep, J., Bühler, K.: Grundzüge der Strömungslehre. Teubner-Verlag

## Course: Hydraulic Fluid Machinery II [2158105]

**Coordinators:** S. Caglar, M. Gabi  
**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral examination  
 Duration: ca. 30 minutes  
 No tools or reference materials may be used during the exam.

### Conditions

Hydraulic Fluid Machinery I (Basics)

### Recommendations

2153412 Fluid mechanics

### Learning Outcomes

Students get to know advanced basics of hydraulic fluid machinery (pumps, fans, hydroturbines, windturbines, hydrodynamic transmissions). Application of the knowledge in different fields of engineering. The lecture introduces, based on the lecture Hydraulic Fluid Machinery I, advanced knowledge in the field of design and operation. The different types and shapes are discussed. Students are able to understand the working and design principle of Hydraulic Fluid Machinery as well as the interaction with typical systems, in which they are integrated.

### Content

Rotodynamic pumps and fans of different types of construction  
 Hydro turbines  
 Wind turbines  
 Hydrodynamic transmissions

### Literature

1. Fister, W.: Fluidenergiemaschinen I & II, Springer-Verlag
2. Siegloch, H.: Strömungsmaschinen, Hanser-Verlag
3. Pfeleiderer, C.: Kreiselpumpen, Springer-Verlag
4. Carolus, T.: Ventilatoren, Teubner-Verlag
5. Bohl, W.: Ventilatoren, Vogel-Verlag
6. Raabe, J.: Hydraulische Maschinen, VDI-Verlag
7. Wolf, M.: Strömungskupplungen, Springer-Verlag
8. Hau, E.: Windkraftanlagen, Springer-Verlag

## Course: Hydrodynamic Stability: From Order to Chaos [2154437]

**Coordinators:** A. Class

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral

Duration: 30 minutes

Auxiliary means: none

### Conditions

Mathematics

### Learning Outcomes

The students can apply the analytic and numerical methods for an evaluation of stability properties of hydrodynamic systems. They are qualified to discuss the characteristic influence of parameter changes (e.g. Reynolds number) on the calculated results with respect to the flow character and properties (e.g. transition laminar/turbulent flow).

### Content

Increasing a control parameter of a thermohydraulic system, e.g. the Reynolds number, the initial flow pattern (e.g. stationary flow) can be replaced by a different pattern (e.g. turbulent flow).

Typical hydrodynamic instabilities are summarized in the lecture.

The systematic analysis of thermohydraulic stability problems is developed for the case of Rayleigh-Bernard convection (fluid layer heated from below) and selected examples from fluid dynamics.

Covered is:

- linear stability analysis: determine limiting control parameter value up to which the basic flow pattern is stable against small perturbations.
- nonlinear reduced order modeling, capable to characterize more complex flow patterns
- Lorenz system: a generic system exhibiting chaotic behavior

### Media

Black board

### Literature

Script

### Remarks

Lecture also offered as a block-lecture within the AREVA Nuclear Professional School ([www.anps.kit.edu](http://www.anps.kit.edu))

**Course: Industrial aerodynamics [2153425]****Coordinators:** T. Breitling**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

no auxiliary means

**Conditions**

None.

**Learning Outcomes**

Students can describe the different challenges of aerodynamical flow that occur in vehicles. They are qualified to analyze external flows around the vehicles, flows in the passenger compartments (thermal comfort), as well as cooling flows, charge motion, mixing and combustion processes in the engine.

**Content**

This compact lecture deals with flow, mixing and combustion phenomena with significance in vehicle development. A special focus is set on the optimization of external car and truck aerodynamics, thermal comfort in passenger compartments, analyses of cooling flows and improvement of charge motion, mixing and combustion in piston engines. These fields are explained in their phenomenology, the corresponding theories are discussed and the tools for measurement and simulation are introduced and demonstrated. The focus of this lecture is on industry relevant methods for analyses and description of forces, flow structures, turbulence, flows with heat transfer and phase transition and reactive flows. In addition an introduction to modern methods in accuracy control and efficiency improvement of numerical methods for industrial use is given. The integration and interconnection of the methods in the development processes are discussed exemplary.

An excursion to the Daimler AG wind tunnel and the research and development centers is planned.

- Industrial flow measurement techniques
- Flow simulation and control of numerical errors, turbulence modeling
- Cooling flows
- Flow mixing and combustion at direct injected Diesel engines
- Flow mixing and combustion at gasoline engine
- Vehicle aerodynamics
- HVAC-Systems and thermal comfort
- Aeroacoustics

**Literature**

Script

**Remarks**

Block course with limited number of participants, registration in the secretary's office required. See details at [www.istm.kit.edu](http://www.istm.kit.edu)

## Course: Introduction to Industrial Production Economics [2109042]

**Coordinators:** S. Dürrschnabel

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

### Conditions

Registration for the lecture via ILIAS necessary.

### Learning Outcomes

- The students know the possible organisational structures for enterprises.
- The students learn about the importance of process data as basis for efficient work structuring.
- The students are able to execute and evaluate time studies in industry (e.g. REFA).
- The students know different methods for the evaluation of working places.
- The students know basic techniques for the determination of wages.
- The students are able to make a cost calculation for a specific product.

### Content

- Configuration of the departmental organisation and the process organisation
- Execution and evaluation of time studies
- Actual tools for time studies, e.g. Work Sampling, Methods-Time Measurement, Planned times,
- Evaluation of workplaces and determination of wages
- Cost accounting (including Process costs)

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- REFA – Verband für Arbeitsstudien und Betriebsorganisation (Hrsg.): Ausgewählte Methoden zur prozessorientierten Arbeitsorganisation. Darmstadt: REFA, 2002.
- SCHLICK, Christopher; BRUDER, Ralph; LUCZAK, Holger: Arbeitswissenschaft. Heidelberg u.a.: Springer, 3rd edition 2010.
- EBEL, Bernd: Produktionswirtschaft. Ludwigshafen am Rhein: Kiehl Friedrich Verlag, 9th edition 2009.

Please refer to the latest edition.

## Course: Occupational Safety and Environmental Protection (in German) [2110037]

**Coordinators:** R. von Kiparski

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

### Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

### Recommendations

- Knowledge of Human Factors Engineering is usefull

### Learning Outcomes

The participant can

- explain the importance of occupational safety and environmental protection as well as their connection to each other.
- describe the influence of human behaviour.
- explain the possibilities and limits for an engineer to influence.
- realise if professional help of an expert of other faculties is needed.
- evaluate and present the results of his work.

### Content

The participants have to solve a specific case study within the field of occupational safety and environmental protection. Therefore, the work in a team. The tasks covers the information research as well as the presentation of the results.

Content:

- Occupational Safety and Safety Engineering
- Environmental Protection within a Production Enterprise
- Health Management

Structure:

- Terminology
- Basics of Occupational Safety and Environmental Protection
- Case Study

- Moderated Processing of a Case Study within a Small Group

**Literature****Learning material:**

Handout and literature online ILIAS.

**Literature:**

- HACKSTEIN, R.: Arbeitswissenschaft im Umriß, Bd.1 und 2, Essen, 1977.
- HÜBLER, K.-H.; OTTO-ZIMMERMANN, K.: Bewertung der Umweltverträglichkeit. Taunusstein, 1989.
- KERN, P.; SCHMAUDE, M.: Einführung in den Arbeitsschutz für Studium und Berufspraxis. München: Hanser, 2005.
- KIPARSKI, R. v.: Rechtliche Grundlagen der Arbeitssicherheit Praxishandbuch für den Betriebsleiter. WEKA Verlag: Augsburg, 1997.
- GROB, R.: Erweiterte Wirtschaftlichkeits- und Nutzenrechnung. Köln, 1984.
- o.V.: Gefahrstoffverordnung 2005.
- o.V.: Geräte- und Produktsicherheitsgesetz 2004.
- o.V.: Arbeitssicherheitsgesetz 1973.
- o.V.: Arbeitsschutzgesetz 1996.
- o.V.: Berufsgenossenschaftliche Vorschriften und Regeln für Sicherheit- und Gesundheit bei der Arbeit.
- o.V.: Wörterbuch 'Arbeitssicherheit und Gesundheitsschutz' Wiesbaden, 2007.

Please refer to the latest edition.

## Course: Information Systems in Logistics and Supply Chain Management [2118094]

**Coordinators:** C. Kilger

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral / written (if necessary) => (see "Studienplan Maschinenbau", version of 29.06.2011)

examination aids: none

### Conditions

none

### Recommendations

none

### Learning Outcomes

Students are able to:

- Describe requirements of logistical processes regarding IT systems,
- Choose information systems to support logistical processes and use them according to the requirements of a supply chain.

### Content

- 1) Overview of logistics systems and processes
- 2) Basic concepts of information systems and information technology
- 3) Introduction to IS in logistics: Overview and applications
- 4) Detailed discussion of selected SAP modules for logistics support

### Media

presentations

### Literature

Stadtler, Kilger: Supply Chain Management and Advanced Planning, Springer, 4. Auflage 2008

### Remarks

none

## Course: Innovation Workshop: Mobility concepts for the year 2050 [2115916]

**Coordinators:** P. Gratzfeld

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

### Learning Control / Examinations

Written report and oral exam

### Conditions

Attendance is mandatory during the whole seminar.

### Recommendations

none

### Learning Outcomes

- The students get aware of the mega and industry trends and learn about the innovation process of an international company in rail industry.
- They exercise advanced creativity techniques.
- They learn and deepen key qualifications like communication skills, presentation skills, moderation techniques and team work.
- They learn the appliance of a business plan as well as the usage of project management by practical examples.

### Content

- Presentation of the company and the industry.
- Long term development of society and environment (megatrends), impact on railways and rail industry.
- Creating, elaborating and discussing innovative ideas by using the innovation tool "Zukunftswerkstatt".
- Different methods (Card Technique, Flash Light, Mind Map, Feedback, Elevator pitch, Business Plan, Project Management)
- Training and coaching of the individual presentation skills with final presentations in front of company representatives.

### Media

All material is available for download (Ilias-platform).

### Literature

Literature will be provided in advance and during the course.

### Remarks

- This seminar is a 5-day block course.
- Number of participants is limited.
- Registration is necessary.
- For further information please look at the website [www.bahnsystemtechnik.de](http://www.bahnsystemtechnik.de).

## Course: Innovative Nuclear Systems [2130973]

**Coordinators:** X. Cheng

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

- oral examination
- duration 20min

### Conditions

None.

### Learning Outcomes

This lecture is addressed to students of mechanical engineering, chemical engineering and physics. Goal of the lecture is the explanation of state-of-the-art development of nuclear systems. Nuclear systems, that are from todays point of view promising will be presented and explained. The main characteristics of such systems and the associated challenges are also part of the lecture.

### Content

1. state of the art and development tendencies in nuclear systems
2. advanced concepts in light water cooled systems
3. new developments in fast reactors
4. development tendencies in gas-cooled plants
5. transmutation systems for waste management
6. fusionsystems

## Course: Introduction to Neutron Cross Section Theory and Nuclear Data Generation [2190490]

**Coordinators:** R. Dagan

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

oral exam, 30 min.

### Conditions

none

### Recommendations

none

### Learning Outcomes

The students:

- Understand the special importance of cross sections in various domains of natural science (Reactor physics, Material research, Solar radiation etc.)
- Are familiar with the theoretical methods and experimental effort to generate cross sections data.

### Content

Cross section characterization  
 Summary of basic cross section theory  
 Resonance cross section  
 Doppler broadening  
 Scattering kernels  
 Basic of slowing down theory  
 Unit cell based XS data generation  
 Cross sections Data libraries  
 Data Measurements

### Literature

Handbook of Nuclear Reactors Calculations Vol. I Y. Ronen, CRC Press 1986  
 D. Emendorfer, K.H. Höcker Theory of nuclear reactions, Parts I, II BI- Hochschultaschenbücher 1969 ( in German)  
 P. Tipler, R. Llewellyn Modern Physics 2008

## Course: IT-Fundamentals of Logistics [2118183]

**Coordinators:** F. Thomas

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral / written (if necessary) => (see "Studienplan Maschinenbau", latest version)

examination aids: none

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

Students are able to:

- Describe and classify automation technology for material flow and the information technology necessary,
- identify, analyze and design the business processes in internal logistics,
- identify risks of failure and counteract and
- transfer the knowledge to practical implementations.

### Content

This lecture, with exercises, treats automation technology in material flow as well as the information technology that has a direct relationship with it. In the first few chapters and exercises, an overview is given of the motors and conveying technology elements used in materials handling, and the sensors required for the purpose are explained. The target control types as well as the topic of coding techniques and RFID (GS1, barcodes, scanner, etc.) are treated in detail. Material flow controls are defined based on these chapters. Among other things, the functions of a stored-memory controller are explained in this section. Hierarchically classified control structures and their integration in network structures are considered in detail. The principles of communications systems (bus systems etc.) are supplemented with information on the use of the Internet as well as data warehousing strategies. An overview of modern logistics systems, especially in stores administration, illustrates new problem solution strategies in the area of information technology for logistics systems. After an analysis of the causes for system failures, measures are worked out for reducing the risks of failure. Furthermore, the objectives, task areas as well as various scheduling strategies in the area of transport management and control are presented. Worthwhile information on Europe-wide logistics concepts round off this practice-oriented lecture series. The presentation of the lectures will be multimedia-based. Exercises repeat and extend the knowledge principles imparted in the lectures and illustrate the subject with practical examples.

Focuses:

- System architecture for logistics solutions / Modularization of conveyors
- Material Flow Control System (MFCS) / Transport Handling
- Coding technique, GS 1 / RFID
- Data communication between controllers, computers and networks
- Business processes for internal logistics – software follows function
- Adaptive IT - Future-oriented software architecture
- System stability and data backup –Software-Engineering

- XTS – The Extensible Transport System

**Literature**

Detailed script can be downloaded online ([www.tup.com](http://www.tup.com)), updated and enhanced annually.

CD-ROM with chapters and exercises at the end of the semester available from the lecturer, also updated and enhanced annually.

**Remarks**

none

## Course: Introduction to Ceramics [2125757]

**Coordinators:** M. Hoffmann

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

### Learning Control / Examinations

The assessment consists of an oral exam (30 min) taking place at the agreed date.

The re-examination is offered upon agreement.

### Conditions

none

### Recommendations

Fundamentals in natural science are recommended for students in mechanical and industrial engineering. The lecture requires the basics of the material science courses in mechanical or industrial engineering for bachelor students.

### Learning Outcomes

The students know the most relevant crystal structures and defects of non metallic inorganic materials, are able to read binary and ternary phase diagrams and are familiar with powder technological shaping techniques, sintering and grain growth. They know the basics of the linear elastic fracture mechanics, are familiar with Weibull statistics, K-concept, subcritical crack growth, creep and the opportunities for microstructural reinforcement of ceramics. The students are able to explain the correlation among chemical bonding, crystal and defect structures and the electrical properties of ceramics.

### Content

After a short introduction to interatomic bonding, fundamental concepts of crystallography, the stereographic projection and the most important symmetry elements will be given. Different types of crystal structures are explained and the relevance of imperfections are analysed with respect to the mechanical and electrical properties of ceramics. Then, the impact of surfaces, interfaces and grain boundaries for the preparation, microstructural evolution and the resulting properties is discussed. Finally, an introduction is given to ternary phase diagrams.

The second part of the course covers structure, preparation and application aspects of nonmetallic inorganic glasses, followed by an introduction to the properties and processing methods of fine-grained technical powders. The most relevant shaping methods, such as pressing, slip casting, injection moulding and extrusion are introduced. Subsequently, the basics of science of sintering and the mechanisms for normal and abnormal grain growth are discussed. Mechanical properties of ceramics are analysed using basic principles of linear elastic fracture mechanics, Weibull statistics, concepts for subcritical crack growth and creep models to explain the behaviour at elevated temperatures. Furthermore it is demonstrated that mechanical properties can be significantly enhanced by various types of microstructural toughening mechanisms. The electronic and ionic conductivity of ceramic materials are explained based on defect-chemical considerations and band structure models. Finally, the characteristics of a dielectric, pyroelectric, and piezoelectric behaviour is discussed.

### Media

Slides for the lecture:

available under <http://www.iam.kit.edu/km>

### Literature

- H. Salmang, H. Scholze, "Keramik", Springer
- Kingery, Bowen, Uhlmann, "Introduction To Ceramics", Wiley
- Y.-M. Chiang, D. Birnie III and W.D. Kingery, "Physical Ceramics", Wiley
- S.J.L. Kang, "Sintering, Densification, Grain Growth & Microstructure", Elsevier

## Course: Ceramics Processing [2126730]

**Coordinators:** J. Binder

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

The assessment consists of an oral exam (approx. 20 min) taking place at the agreed date.

Auxiliary means: none

The re-examination is offered upon agreement.

### Conditions

none

### Recommendations

Basics of the course "Introduction to Ceramics" should be known.

### Learning Outcomes

The students are able to name the major ceramic process technologies and explain their specifics in detail. Additionally, they are capable of illustrating the correlations between the individual processes and their importance for the production of engineering ceramics. The students are able to relate processing effects to material properties. Furthermore the students can apply the basics to concrete tasks. They are able to comprehend and assess information in professional articles.

### Content

The course imparts technological basics for processing of engineering ceramics. The course is arranged in the following units:

- Synthesis methods
- Powder conditioning and mixing methods
- Forming of ceramics
- Sintering
- Finishing processes
- Ceramic films and multi-layer systems
- Effects of processing on properties

### Literature

W. Kollenberg: Technische Keramik, Vulkan Verlag 2010.

M. N. Rahaman: Ceramic Processing, CRC Taylor & Francis, 2007.

D.W. Richerson: Modern ceramic engineering, CRC Taylor & Francis, 2006.

A. G. King: Ceramic Technology and Processing, William Andrew, 2002.

## Course: Nuclear Power Plant Technology [2170460]

**Coordinators:** T. Schulenberg, K. Litfin

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

### Conditions

None.

### Learning Outcomes

The students know the design and operation of major components of nuclear power plants with pressurized water reactors and boiling water reactors.

### Content

Power plants with pressurized water reactors:

Design of the pressurized water reactor

- Fuel assemblies
- Control rods and drives
- Core instrumentation
- Reactor pressure vessel and its internals

Components of the primary system

- Primary coolant pumps
- Pressurizer
- Steam generator
- Water make-up system

Secondary system:

- Turbines
- Reheater
- Feedwater system
- Cooling systems

Containment

- Containment design
- Components of safety systems
- Components of residual heat removal systems

Control of a nuclear power plant with PWR

Power plants with boiling water reactors:

Design of the boiling water reactor

- Fuel assemblies
- Control elements and drives
- Reactor pressure vessel and its internals

Containment and components of safety systems

Control of a nuclear power plant with boiling water reactors

**Media**

Powerpoint presentations

**Literature**

lecture notes

**Remarks**

The lecture "Nuclear Power Plant Technology" given in the winter semester has been cancelled instead

**Course: Coal fired power plants [2169461]****Coordinators:** P. Fritz, T. Schulenberg**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

Knowledge in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.

**Recommendations**

None.

**Learning Outcomes**

After completion, the students know the layout of different coal fired power plants, the design of their major components, as well as the operational conditions and their limits.

**Content**

The lecture presents the technology of coal fired power plants, which are conventional steam turbine plants as well as advanced combined cycle power plants with integrated coal gasification. It includes combustion systems, steam generators, a short overview over steam turbine technologies, the cooling system and the water supply system as well as the off gas treatment. Coal gasification will be explained with fixed bed, fluidized bed and entrained flow gasifiers. The integrated coal gasification combined cycle includes also the raw gas purification system. In addition, a visit to a coal fired power plant will be offered.

**Media**

power point presentation

**Literature**

Everett B. Woodruff, Herbert B. Lammers, Thomas F. Lammers, Steam Plant Operation, 9th Edition, McGraw Hill, New York 2012

**Course: Design with Plastics [2174571]****Coordinators:** M. Liedel**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral duration: 20 - 30 min. aids: none

**Conditions**

none, recomm. 'Polymer Engineering I'

**Learning Outcomes**

Students will be able to

- distinguish polymer compounds from other construction materials regarding chemical differences, thermal behaviour and solid conditions.
- discuss main plastics processes regarding advantages and disadvantages of materials selection and part geometry design and to make appropriate selections.
- analyze complex application requirements concerning material impacts on strength and to use the classic dimensioning method specific to the application to evaluate the lifetime part strength limit.
- evaluate part tolerances and geometry by appropriate methods considering molding shrinkage, production tolerances, post shrinkage, heat expansion, swelling, elastic and creep deformation.
- design plastic specific joining geometries like snap fits, screw bosses, weld seams and film hinges.
- detect classic molding failures and understand potential causes as well as to reduce the probability of molding failures by defining an optimized design.
- understand benefits and limits of selected simulation tools in the plastic technology discipline (strength, deformation, filling, warpage).
- assess polymer classes and plastic part designs with respect to suitable recycling concepts and ecological consequences.

**Content**

Structure and properties of plastics materials,  
 Processing of plastics,  
 Behavior of plastics under environmental impacts,  
 Classic strength dimensioning,  
 Geometric dimensioning,  
 Plastic appropriate design,  
 Failure examples,  
 Joining of plastic parts,  
 Supporting simulation tools,  
 Structural foams,  
 Plastics Technology trends.

**Literature**

Scriptum will be handed out during the lecture.  
 Recommended literature are provided in the lecture.

**Course: Structural Materials [2174580]****Coordinators:** K. Lang**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Summer term | de                   |

**Learning Control / Examinations**

Oral or Written Exam

**Conditions**

None.

**Learning Outcomes**

The students are able to select materials for mechanical design and to dimension structural components according to the state of the art. They are familiar with the most important engineering materials. They can assess these materials on base of their characteristic properties and and they can match property profiles and requirement profiles. The dimensioning includes complex situations, such as multiaxial loading, notched components, static and dynamic loading, componetns with residual stresses and loading at high homologous temperatures.

**Content**

Lectures and tutorialy on the topics:

- basic loading types and superimposed loadings
- high-temperature loading
- influence of notches
- uniaxial, multiaxial and superimposed cyclic loading
- notch fatigue
- structural durability
- impact of residual stresses
- basic principles of materials selection
- dimensioning of components

## Course: Lightweight Engineering Design [2146190]

**Coordinators:** A. Albers, N. Burkardt

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

The type of examination (written or oral) will be announced at the beginning of the lecture.

written examination: 60 min duration

oral examination: 20 min duration

Auxiliary means: none.

### Conditions

none

### Learning Outcomes

The students are able to ...

- name the central strategies of lightweight construction and their connections and to illustrate them on examples.
- list different stiffening methods in relation to computer-based design.
- evaluate the capacity of computer-based design as well as the related limits and influences on the manufacturing.
- reflect the basics of lightweight construction in the overall framework related to the product engineering process.

### Content

General aspects of lightweight design, lightweight strategies, construction methods, design principles, lightweight construction, stiffening techniques, lightweight materials, virtual product engineering, bionics, joining techniques, validation, recycling

Additionally, guest speakers from industry will present lightweight design from an practical point of view.

### Media

Beamer

### Literature

Klein, B.: Leichtbau-Konstruktion. Vieweg & Sohn Verlag, 2007

Wiedemann, J.: Leichtbau: Elemente und Konstruktion, Springer Verlag, 2006

Harzheim, L.: Strukturoptimierung. Grundlagen und Anwendungen. Verlag Harri Deutsch, 2008

### Remarks

Lecture slides are available via eLearning-Platform ILIAS.

## Course: Vibration of continuous systems [2161214]

**Coordinators:** H. Hetzler

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral exam., 30min

### Conditions

None.

### Learning Outcomes

#### Content

This lecture is on vibrations of continuous systems. After an introduction into the topic and a definition of basic concepts and calculation approaches, 1-parametric continua (strings, bars) and 2-parametric continua (membranes, plates) are discussed into detailed. Based on these basic models, a brief outlook to more complex geometries is given. Beyond these basis issues more advanced topics (like elastic rotors) are discussed as well.

#### Literature

Literature recommendations are given in the lecture.

**Course: Motor Vehicle Laboratory [2115808]****Coordinators:** M. Frey, M. Bürckert**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Colloquium before each experiment

After completion of the experiments: written examination

Duration: 90 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students have deepened their knowledge on motor vehicles acquired in lectures and can apply it practically. They have an overview of the applied measuring technique and can execute and analyse measurements for the handling of given problem definitions. They are ready to analyze and to judge measurement results.

**Content**

1. Determination of the driving resistances of a passenger vehicle on a roller dynamometer; measurement of the engine performance of the test vehicle
2. Investigation of a twin-tube and a single-tube shock absorber
3. Behavior of car tyres under longitudinal forces and lateral forces
4. Behavior of car tires on wet road surface
5. Rolling resistance, energy dissipation and high-speed strength of car tires
6. Investigation of the moment transient characteristic of a Visco clutch

**Literature**

1. Matschinsky, W: Radführungen der Straßenfahrzeuge, Verlag TÜV Rheinland, 1998
2. Reimpell, J.: Fahrwerktechnik: Fahrzeugmechanik, Vogel Verlag, 1992
3. Gnadler, R.: Documents to the Motor Vehicle Laboratory

## Course: Cooling of thermally high loaded gas turbine components [2170463]

**Coordinators:** H. Bauer, A. Schulz

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

### Conditions

None.

### Learning Outcomes

The students are able to:

- name and differentiate between different cooling methods and analyse them
- judge on the advantages and disadvantages of cooling methods and discuss approaches for the improvement of complex cooling methods
- to outline the basics of forced convective heat transfer and film cooling
- design cooled gas turbine components in a simplified manner
- comment on the experimental and numerical methods for the characterisation of heat transfer

### Content

Hot gas temperatures of modern gas turbine engines exceed the maximum tolerable material temperatures by several hundreds of K. To ensure reliability of lifetime, complex cooling technology must be applied. Various cooling methods will be introduced in this lesson. Specific pros and cons will be identified and new concepts for further improvement of cooling will be discussed. Furthermore, the fundamentals of forced convection heat transfer and film cooling will be imparted and a simplified design process of a cooled gas turbine components will be demonstrated. Finally, experimental and numerical methods for the characterization of heat transfer will be presented.

## Course: Laboratory Work in Combustion Technology [22531]

**Coordinators:** N. Zarzalis

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

The examination results from the chosen module, otherwise:  
oral examination (not graded)

### Conditions

Fluid dynamic, heat transfer

### Recommendations

The “laboratory work in combustion technology” is a very good completion to the lesson “applied combustion technology”

### Learning Outcomes

After completing the course students can:

- Measure the temperature inside the flame by means of thermocouples
- Perform an exhaust gas analysis
- Determine the degree of burn out from the exhaust analysis data
- Determine the efficiency of a furnace
- Determine the stability range of a burner
- Determine the laminar flame velocity according the bomb method

### Content

The LAB-CT consists of 4 experiments dealing with:

- Energy conversion
- Unsteady flame propagation in a pressure vessel
- Swirl-stabilized flames
- Combustion in porous inert media

## Course: Warehousing and distribution systems [2118097]

**Coordinators:** M. Schwab, J. Weiblen

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral / written (if necessary) => (see "Studienplan Maschinenbau", version 29.06.2011)

### Conditions

none

### Recommendations

logistics lecture

### Learning Outcomes

Students are able to:

- Describe the areas of typical warehouse and distribution systems with the respective processes and can illustrate it with sketches,
- Use and choose strategies of warehouse and distribution systems according to requirements,
- Classify typical systems using criteria discussed in the lecture, and
- Reason about the choice of appropriate technical solutions.

### Content

- Introduction
- Yard management
- Receiving
- Storage and picking
- Workshop on cycle times
- Consolidation and packing
- Shipping
- Added Value
- Overhead
- Case Study: DCRM
- Planning of warehouses
- Case study: Planning of warehouses
- Distribution networks
- Lean Warehousing

### Media

presentations, black board

### Literature

**ARNOLD, Dieter, FURMANS, Kai (2005)**

Materialfluss in Logistiksystemen, 5. Auflage, Berlin: Springer-Verlag

**ARNOLD, Dieter (Hrsg.) et al. (2008)**

Handbuch Logistik, 3. Auflage, Berlin: Springer-Verlag

**BARTHOLDI III, John J., HACKMAN, Steven T. (2008)**

Warehouse Science

**GUDEHUS, Timm (2005)**

Logistik, 3. Auflage, Berlin: Springer-Verlag

**FRAZELLE, Edward (2002)**

World-class warehousing and material handling, McGraw-Hill

**MARTIN, Heinrich (1999)**

Praxiswissen Materialflußplanung: Transport, Hanshaben, Lagern, Kommissionieren, Braunschweig, Wiesbaden: Vieweg

**WISSER, Jens (2009)**

Der Prozess Lagern und Kommissionieren im Rahmen des Distribution Center Reference Model (DCRM); Karlsruhe : Universitätsverlag

A comprehensive overview of scientific papers can be found at:

**ROODBERGEN, Kees Jan (2007)**

Warehouse Literature

**Remarks**

none

**Course: Laser in automotive engineering [2182642]****Coordinators:** J. Schneider**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination (30 min)

no tools or reference materials

**Conditions**

Basic knowledge of physics, chemistry and material science is assumed.

It is not possible, to combine this lecture with the lecture *Physical basics of laser technology* [2181612].**Recommendations**

None.

**Learning Outcomes**

The student

- can explain the principles of light generation, the conditions for light amplification as well as the basic structure and function of Nd:YAG-, CO<sub>2</sub>- and high power diode-laser sources.
- can describe the most important methods of laser-based processing in automotive engineering and illustrate the influence of laser, material and process parameters
- can analyse manufacturing problems and is able to choose a suitable laser source and process parameters.
- can explain the requirements for safe handling of laser radiation and for the design of safe laser systems.

**Content**

Based on a short description of the physical basics of laser technology the lecture reviews the most important high power lasers and their various applications in automotive engineering. Furthermore the application of laser light in metrology and safety aspects will be addressed.

- physical basics of laser technology
- laser beam sources (Nd:YAG-, CO<sub>2</sub>-, high power diode-laser)
- beam properties, guiding and shaping
- basics of materials processing with lasers
- laser applications in automotive engineering
- economical aspects
- safety aspects

**Media**

lecture notes via ILIAS

**Literature**

W. M. Steen: Laser Material Processing, 2010, Springer

W. T. Silfvast: Laser Fundamentals, 2008, Cambridge University Press

**Remarks**

It is allowed to select only one of the lectures "Laser in automotive engineering" (2182642) or "Physical basics of laser technology" (2181612) during the Bachelor and Master studies.

## Course: Leadership and Product Development [2145184]

**Coordinators:** A. Ploch

**Part of the modules:** Elective Subject Economics/Law (p. 61)[MSc-Modul 12, WF WR], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term |                      |

### Learning Control / Examinations

oral exam

### Conditions

none

### Learning Outcomes

The students are able to name, explain und discuss the main elements of leadership theories, methods and management development basics as well as the bordering topics of change management, intercultural competences, team work and corporate governance.

### Content

Leadership theories  
 Management tools  
 Communication as management tool  
 Change management  
 Management development and MD-Programs  
 Assessment center and management audits  
 Team work, team development und team roles  
 Intercultural competences  
 Leadership and ethics, Corporate Governance  
 Executive Coaching  
 Lectures of industrial experts

## Course: Laboratory Exercise in Energy Technology [2171487]

**Coordinators:** H. Bauer, U. Maas, H. Wirbser

**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 4              | Winter / Summer Term | de                   |

### Learning Control / Examinations

1 report, approx. 12 pages

Discussion of the documented results with the assistants

Duration: 30 minutes

no tools or reference materials may be used

### Conditions

none

### Recommendations

none

### Learning Outcomes

Attending this course enables the students to:

- accomplish experimental and design related as well as theoretical tasks in a scientific background
- perform a correct evaluation of the obtained results
- adequately document and present their results in a scientific framework

### Content

- Micro gas turbine
- Several test rigs for the investigation of heat transfer at thermally high loaded components
- Optimization of components of the internal air and oil system
- Characterization of spray nozzles
- Investigation of pollutant and noise emission as well as reliability and material deterioration
- Exhaust gas treatment
- Exhaust gas turbocharger
- Cooling Tower
- Heatpump
- Plant oil stove
- Heatcapacity
- Wood combustion

### Remarks

Online registration within the first two weeks of the lecture periode at: <http://www.its.kit.edu>

**Course: Logistics - organisation, design and control of logistic systems [2118078]****Coordinators:** K. Furmans**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Summer term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", version of 29.06.2011)

examination aids: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Students are able to:

- Describe logistical tasks,
- Design logistical systems suitable to the respective task,
- Dimension stocastical stock models,
- Determine essential influencing parameters on the bullwhip effect and
- Use optimizing solution methods.

**Content**

multistage logistic process chains

transport chain in logistic networks

distribution processes

distribution centers

logistics of production systems

dependencies between production and road traffic

information flow

cooperative strategies (like kanban, just-in-time, supply chain management)

**Media**

presentations, black board

**Literature**

None.

**Remarks**

none

**Course: Automotive Logistics [2118085]****Coordinators:** K. Furmans**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", version of 29.06.2011)

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Students are able to:

- Describe essential logistic questions, in a complex production network. As an example the automobile industry is used.
- Choose and apply solution possibilities for logistic problems in this area.

**Content**

- Logistic questions within the automobile industry
- basic model of automobile production and distribution
- relation with the suppliers
- Disposition and physical execution
- Vehicle production in the interaction of shell, paint shop and assembly
- Sequence planning
- Assembly supply
- vehicle distribution and linkage with selling processes
- Physical execution, planning and control

**Media**

presentations, black board

**Literature**

None.

**Remarks**

none

**Course: Airport logistics [2117056]****Coordinators:** A. Richter**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", version of 29.06.2011)

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Students are able to:

- Describe material handling and information technology activities on airports,
- Evaluate processes and systems on airports as the law stands, and
- Choose appropriate processes and material handling systems for airports.

**Content**

Introduction  
 airport installations  
 luggage transport  
 passenger transport  
 security on the airport  
 legal bases of the air traffic  
 freight on the airport

**Media**

presentations

**Literature**

None.

**Remarks**

none

**Course: Machine Vision [2137308]****Coordinators:** C. Stiller, M. Lauer**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes

no reference materials

**Conditions**

Basic studies and preliminary examination; fundamentals in measurement, system and control theory, e.g. from the lecture "Measurement and Control Systems"

**Learning Outcomes**

Machine vision (or computer vision) describes the computer supported solution of visual tasks similar to a human. The technical domain machine vision incorporates numerous research areas like optics, digital image processing, 3D measurement technology and pattern recognition. One main focus is image understanding having the goal to gather the meaning of an image and draw conclusions from this semantic meaning. The subjects in the course machine vision are similar to the standard image processing procedure. The students shall acquire an overview on major Machine Vision methods and gather practical experience from computer exercises and experiments.

**Content**

1. Illumination
2. Image acquisition
3. Image preprocessing
4. Feature extraction
5. Stereo Vision
6. Robust parameter estimation
7. Classification and interpretation

**Literature**

Main results are summarized in pdf-file. Further recommendations will be presented in the lecture.

## Course: Magnet Technology of Fusion Reactors [2190496]

**Coordinators:** W. Fietz, K. Weiss

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

### Learning Control / Examinations

Oral examination of about 30 minutes

### Conditions

None.

### Recommendations

Knowledge in energy technology, power plants, material testing is welcomed

### Learning Outcomes

The students know:

- Basic knowledge of superconductivity, superconducting cables and magnet construction
- Generation of low temperature, cryostat construction
- Material properties at low temperatures
- Magnet design and magnet safety
- High-temperature superconductor use in power application and magnet construction

### Content

The goal of the lecture is to impart the fundamentals of construction of superconducting magnets. Magnet technology is inherently of multidisciplinary character e.g. material properties at low temperature, high voltage and high current technique. The use of superconductors is mandatory to reach highest magnetic fields with comparable small losses. Examples of magnets from power application, basic research and fusion reactor construction are discussed.

### Lecture Content:

- Introduction to plasma, fusion and electromagnets
- Introduction superconductivity - basics and materials
- Creation of low temperatures, cryo-technique
- Material properties at low temperature
- Magnet design and calculation
- Magnet stability, quench safety and high voltage protection
- Magnet examples
- High-temperature superconductors (HTS)
- HTS-application (cable, motor/generator, FCL, current leads, fusion reactors)

**Course: Magnetohydrodynamics [2153429]****Coordinators:** L. Bühler**Part of the modules:** Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral,  
 Duration: 30 minutes  
 No auxiliary means

**Conditions**

none

**Learning Outcomes**

The students can describe the fundamentals of magnetohydrodynamics. They are qualified to explain the interrelations of electro and fluid dynamics so as to analyze magnetohydrodynamic flows in engineering applications or for phenomena in geo and astrophysics.

**Content**

- Introduction
- Basics of electro and fluid dynamics
- Exact solutions, Hartmann flow, pump, generator, channel flows
- Inductionless approximation
- Developing flows, change of cross-section, variable magnetic fields
- Alfvén waves
- Stability, transition to turbulence
- Liquid dynamos

**Literature**

U. Müller, L. Bühler, 2001, Magnetofluidynamics in Channels and Containers, ISBN 3-540-41253-0, Springer  
 R. Moreau, 1990, Magnetohydrodynamics, Kluwer Academic Publisher  
 P. A. Davidson, 2001, An Introduction to Magnetohydrodynamics, Cambridge University Press  
 J. A. Shercliff, 1965, A Textbook of Magnetohydrodynamics, Pergamon Press

## Course: Leadership and Conflict Management (in German) [2110017]

**Coordinators:** H. Hatzl

**Part of the modules:** Elective Subject Economics/Law (p. 61)[MSc-Modul 12, WF WR], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

**Optional Subject Economics/Law:** oral exam (ca. 30 min)

### Conditions

- Compact course
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

### Recommendations

- Knowledge of Work science and economics is usefull

### Learning Outcomes

- Knowledge about techniques for management and leadership
- Preparation for the management and leadership in the job

### Content

1. Introduction to the course
2. Goal definition and goal achievement
3. Management techniques within planning
4. Communication and information
5. Decision-making
6. Leadership and co-operation
7. Self management
8. Conflict management
9. Case studies

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- ALLHOFF, D.-W.; ALLHOFF, W.: Rhetorik und Kommunikation. Regensburg: Bayerischer Verlag für Sprechwissenschaft, 2000.

- ARMSTRONG, M.: Führungsgrundlagen. Wien, Frankfurt/M.: Ueberreuter, 2000.
- BUCHHOLZ, G.: Erprobte Management-Techniken. Renningen-Malmsheim : expert-Verlag, 1996.
- RICHARDS, M. D.; GREENLAW, P. S.: Management Decision Making. Homewood: Irwin, 1966.
- SCHNECK, O.: Management-Techniken, Frankfurt/M., New York: Campus Verlag, 1996.

Please refer to the latest edition.

**Course: Machine Dynamics [2161224]****Coordinators:** C. Proppe

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | en                   |

**Learning Control / Examinations**

Written examination (compulsory subject), auxiliary means: own manuscripts  
 Oral examination (optional subject) , no auxiliary means allowed

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Students are able to apply engineering-oriented calculation methods in order to model and to understand dynamic effects in rotating machinery. This includes the investigation of runup, stationary operation of rigid rotors including balancing, transient and stationary behavior of flexible rotors, critical speeds, dynamics of slider-crank mechanisms, torsional oscillations.

**Content**

1. Introduction
2. Machine as mechatronic system
3. Rigid rotors: equations of motion, transient and stationary motion, balancing
4. Flexible rotors: Laval rotor (equations of motion, transient and stationary behavior, critical speed, secondary effects), refined models)
5. Slider-crank mechanisms: kinematics, equations of motion, mass and power balancing

**Literature**

Biezeno, Grammel: Technische Dynamik, 2. Edition, 1953

Holzweißig, Dresig: Lehrbuch der Maschinendynamik, 1979

Dresig, Vulfson: Dynamik der Mechanismen, 1989

**Course: Machine Dynamics II [2162220]****Coordinators:** C. Proppe**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

**Learning Control / Examinations**

oral exam, no auxiliary means allowed

**Conditions**

none

**Recommendations**

Machine Dynamics

**Learning Outcomes**

Students are able to develop and analyze detailed models in machine dynamics that encompass continuum models, fluid structure interaction, and stability analyses.

**Content**

- hydrodynamic bearings
- rotating shafts in hydrodynamic bearings
- belt drives
- vibration of turbine blades

**Literature**

R. Gasch, R. Nordmann, H. Pfützner: Rotordynamik, Springer, 2006

## Course: Material flow in logistic systems [2117051]

**Coordinators:** K. Furmans

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

### Learning Control / Examinations

oral / written (if necessary) => (see "Studienplan Maschinenbau", current version)

### Conditions

none

### Recommendations

Recommended compulsory optional subject:  
Stochastics in mechanical engineering

### Learning Outcomes

Students are able to:

- describe material flow processes qualitativ and quantitativ,
- assign possibilities of technical solutions to a open operational task,
- plan material flow systems, illustrate them in simple models and analyse them regarding their performance,
- use methods to determine performance indicators like throughput, utilization, etc., and
- evaluate material flow systems regarding performance and availability.

### Content

- elements of material flow systems (conveyor elements, fork, join elements)
- models of material flow networks using graph theory and matrices
- queueing theory, calculation of waiting time, utilization
- warehouseing and order-picking
- shuttle systems
- sorting systems
- simulation
- calculation of availability and reliability
- value stream analysis

### Media

presentations, black board, book

### Literature

**Arnold, Dieter; Furmans, Kai** : Materialfluss in Logistiksystemen; Springer-Verlag Berlin Heidelberg, 2009

### Remarks

none

**Course: Materialien für elektrochemische Speicher und Wandler [2174601]****Coordinators:****Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content**

## Course: Materials and Processes for Body Lightweight Construction in the Automotive Industry [2149669]

**Coordinators:** D. Steegmüller, S. Kienzle

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None

### Recommendations

None

### Learning Outcomes

The students . . .

- are able to name the various lightweight approaches and identify possible areas of application.
- are able to identify the different production processes for manufacturing lightweight structures and explain their functions.
- are able to perform a process selection based on the methods and their characteristics.
- are able to evaluate the different methods against lightweight applications on the basis of technical and economic aspects.

### Content

The objective of the lecture is to build up an overview of the relevant materials and processes for the production of a lightweight body. This includes both the actual production and the joining for the body. The lecture covers the different lightweight approaches and possible fields of application in the automotive industry. The methods are discussed with practical examples from the automotive industry.

The following topics will be covered:

- lightweight designs
- aluminum and steel for lightweight construction
- fibre-reinforced plastics by the RTM and SMC process
- joining of steel and aluminum (clinching, riveting, welding)
- bonding
- coating
- finishing
- quality assurance
- virtual factory

### Media

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

### Literature

Lecture Notes

### Remarks

None

## Course: Mathematical Modelling and Simulation [0109400]

**Coordinators:** G. Thäter, V. Heuveline

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

### Learning Control / Examinations

The examination results from the chosen module, otherwise:  
oral examination

### Conditions

none

### Learning Outcomes

- 1) Broad horizon of modelling tools
- 2) (Un)stability and (un)reliability of models
- 3) Adequate accuracy and verification

### Content

Mathematics as way of thinking (via modelling) and as technique (i.e. providing tools) meets problems arising in everyday life. The problems themselves are easy to understand and the lecture will not rely on too much previous knowledge. Basic understanding of probability and Ordinary Differential equations will be enough. But you should bring along some enthusiasm to use computers. Themes will comprise

- 1) Difference equations
- 2) Population models
- 3) Traffic modelling
- 4) Game theory
- 5) Chaos
- 6) Problems in mechanics and fluid dynamics

This course is well-suited for the first term.

## Course: Mathematical Foundation for Computational Mechanics [2162240]

**Coordinators:** E. Schnack

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral examination. Duration: 30 minutes.

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

The aim is the efficient and targeted application of mathematical methods for modern numerics in mechanical engineering. Students will gain fundamental knowledge of mathematical methods for variational calculus for elastic, dynamic and multi-field continuum calculations. They will gain knowledge of functional analysis which will enable them to understand error estimations in the finite element method (FEM) and the boundary element method (BEM).

### Content

Variational formulations. Functional analysis. Lagrange d process. Various function space definitions relating to the elasticity and dynamics of the mechanics. Measurements which enable the field calculation to be defined in applications.

### Literature

Script (available in administration office, building 10.91, rm. 310).

**Course: Mathematical Methods in Dynamics [2161206]****Coordinators:** C. Proppe**Part of the modules:** Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Mathematic Methods (p. 57)[MSc-Modul 08, MM], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 2              | Winter term | de                   |

**Learning Control / Examinations**

written examination (compulsory subject), auxiliary means: own manuscripts allowed  
 oral examination (optional subject) no auxiliary means allowed

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The students know the mathematical methods of dynamics precisely. They are able to use the basic mathematical methods for modelling the dynamical behaviour of elastic and rigid bodies.

The students have a basic understanding of the description of kinematics and kinetics of bodies. They also master the alternative formulations based on weak formulations and variational methods and the approximate solution methods for numerical calculations of the moving behaviour of elastic bodies.

**Content**

Dynamics of continua:

Concept of continuum, geometry of continua, kinematics and kinetics of continua

Dynamics of rigid bodies:

Kinematics and kinetics of rigid bodies

Variational principles:

Principle of virtual work, variational calculations, Principle of Hamilto

Approximate solution methods:

Methods of weighted residuals, method of Ritz

Applications

**Literature**

Lecture notes (available online)

J.E. Marsden, T.J.R. Hughes: Mathematical foundations of elasticity, New York, Dover, 1994

P. Haupt: Continuum mechanics and theory of materials, Berlin, Heidelberg, 2000

M. Riemer: Technische Kontinuumsmechanik, Mannheim, 1993

K. Willner: Kontinuums- und Kontaktmechanik : synthetische und analytische Darstellung, Berlin, Heidelberg, 2003

J.N. Reddy: Energy Principles and Variational Methods in applied mechanics, New York, 2002

A. Boresi, K.P. Chong, S. Saigal: Approximate solution methods in engineering mechanics, New York, 2003

## Course: Mathematical Methods in Strength of Materials [2161254]

**Coordinators:** T. Böhlke

**Part of the modules:** Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Mathematic Methods (p. 57)[MSc-Modul 08, MM], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Winter term | de                   |

### Learning Control / Examinations

depending on choice according to actual version of study regulations

Additives as announced

Prerequisites are met by solution of homework problems

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

The students can

- perform the most important tensor operations in example problems
- classify tensors of second order according to their properties
- apply elements of tensor analysis
- describe the kinematics of infinitesimal and finite deformations in tensorial notation
- derive balance laws of mechanics
- solve problems of elasticity and thermoelasticity using tensor notation
- apply the theoretical concepts of the lecture to special problems

### Content

Tensor algebra

- vectors; basis transformation; dyadic product; tensors of 2nd order
- properties of 2nd order tensors: symmetry, anti-symmetry, orthogonality etc.
- eigenvalue problem, theorem of Cayley-Hamilton, invariants; tensors of higher order
- tensor algebra in curvilinear coordinate systems
- tensor analysis in curvilinear coordinate systems
- Differentiation of tensor functions

Application of tensor calculus in strength of materials

- kinematics of infinitesimal and finite deformations
- transport theorem, balance equations, stress tensor
- theory of elasticity

- thermo-elasticity

**Literature**

lecture notes

Bertram, A.: Elasticity and Plasticity of Large Deformations - an Introduction. Springer 2005.

Liu, I-S.: Continuum Mechanics. Springer, 2002.

Schade, H.: Tensoranalysis. Walter de Gruyter, New York, 1997.

Wriggers, P.: Nichtlineare Finite-Element-Methoden. Springer, 2001.

## Course: Mathematical methods of vibration theory [2162241]

**Coordinators:** W. Seemann

**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Mathematic Methods (p. 57)[MSc-Modul 08, MM], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

### Learning Control / Examinations

written or oral exam

Announcement 6 weeks prior to examination date.

### Conditions

Technische Mechanik III, IV / Engineering Mechanics III, IV

### Learning Outcomes

The students know to solve single differential equations with constant coefficients by various methods. For inhomogeneous differential equations the inhomogeneity may be arbitrary. They realize the relations between the different methods. For matrix-differential equations the students may derive the eigenvalue problem for free vibration and may obtain solutions for eigenvalues and eigenvectors. They know the modal transformation which is helpful to solve forced vibration. They may decide about stability of time-independent steady state solutions of nonlinear systems. They can derive boundary value problems by variational methods and know in principle how to solve them. For simple one-dimensional continua they may get analytical solutions. They can apply perturbation methods to derive analytical solutions for problems with small parameters.

### Content

Linear, time-invariant, ordinary single differential equations: homogeneous solution; harmonic, periodic and non-periodic excitations; Duhamel's integral; Fourier and Laplace transform; introduction into the theory of distributions; Systems of ordinary differential equations: matrix notation, eigenvalue theory, fundamental matrix, forced vibrations via modal expansion and transition matrix; Introduction into the dynamic stability theory; Partial differential equations: solution in product form, eigenvalue theory, modal expansion using Ritz series; Variational methods, Hamilton's principle, boundary value problems representing vibrating continua; Perturbation methods

### Literature

Riemer, Wedig, Wauer: Mathematische Methoden der Technischen Mechanik

**Course: Mathematical Methods in Fluid Mechanics [2154432]****Coordinators:** A. Class, B. Frohnafel**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Mathematic Methods (p. 57)[MSc-Modul 08, MM], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

written

Duration: 3 hours

Aux. means: formules, pocket calculator

**Conditions**

None.

**Recommendations**

Basic Knowledge about Fluid Mechanics

**Learning Outcomes**

The students can to simplify the Navier-Stokes equations for specific flow problems. They are able to employ mathematical method in fluid mechanics effectively in order to solve the resulting conservation equations analytically, if possible, or to enable simpler numerical access to the problem. They can describe the limits of applicability of the assumptions made to model the flow behavior.

**Content**

The lecture will cover a selection of the following topics:

- Curvilinear coordinates and tensor calculus
- Potential flow theory
- Boundary-layer theory
- Laminar-turbulent transition (linear stability theory)
- Turbulent flows
- Numerical solution of the governing equation (finite difference methods)

**Media**

chalk board, Power Point

**Literature**

Kundu, P.K., Cohen, K.M.: Fluid Mechanics, Elsevier, 4th Edition, 2008

Batchelor, G.K.: An Introduction to Fluid Dynamics, Cambridge Mathematical Library, 2000

Boiko, A. V., Grek, G. R., Dovgal, A. V., Kozlov, V. V.: The Origin of Turbulence in Near-Wall Flows, Springer, 2002

Pope, S. B.: Turbulent Flows, Cambridge University Press, 2000

Ferziger, H., Peric, M.: Computational Methods for Fluid Dynamics, Springer, 2008

**Remarks**

The lecture is accompanied by a tutorial (2154433) where the application of the methods can be practised.

## Course: Mathematical Methods in Structural Mechanics [2162280]

**Coordinators:** T. Böhlke

**Part of the modules:** Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Mathematic Methods (p. 57)[MSc-Modul 08, MM], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

### Learning Control / Examinations

depending on choice according to actual version of study regulations

Additives as announced

Prerequisites are met by solving homework problems

### Conditions

None.

### Recommendations

This course is geared to MSc students.

### Learning Outcomes

The students can

- apply methods of variational calculus for solving problems of linear elasticity
- assess mesoscopic and macroscopic können mesoskopische und makroskopische Spannungs- und Dehnungsmaße beurteilen
- apply and evaluate the methods of homogenization of elastic and thermo-elastic properties
- list methods of homogenization of elastic-plastic properties
- solve worksheet problems to topics of the lecture using technical-mathematical software

### Content

Basics of variational calculus

- functionals; Frechet-differential; Gateaux-differential; maximum or minimum problems
- lemma of variational calculus and Lagrange delta-process; Euler-Lagrange-equations

Applications: Principals of continuums mechanics

- variational principals in mechanics; variational formulierung of boundary value problem of elastostatic

Applications: Homogenization methods for materials with microstructure

- mesoscopic and macroscopic stress and strain measures
- Mean values of ensembles, ergodicity
- effective elastic properties
- Homogenization of thermo-elastic properties
- Homogenization of plastic and visco-plastic properties
- Fe-based homogenization

**Literature**

Vorlesungsskript

Gummert, P.; Reckling, K.-A.: Mechanik. Vieweg 1994.

Gross, D., Seelig, T.: Bruchmechanik – Mit einer Einführung in die Mikromechanik. Springer 2002.

Klingbeil, E.: Variationsrechnung, BI Wissenschaftsverlag, 1977

Torquato, S.: Random Heterogeneous Materials. Springer, 2002.

**Course: Mathematical models and methods in combustion theory [2165525]****Coordinators:** V. Bykov, U. Maas**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The attendance of this course enables students to:

- apply the fundamental concepts of combustion modelling.
- develop ideal models for the description of auto-ignition, explosions, flame quenching and detonations.
- understand the basic mathematical (asymptotic) methods applied in the analysis of these models.
- perform a mathematical analysis of the models.
- determine the mathematical properties of the solutions obtained from the models.

**Content**

The lecture shall introduce the basics of the mathematical modeling and the analysis of reacting flows. The fundamental methods of the modeling of combustion processes are outlined and asymptotical methods, which deliver reasonable approximations for numerous combustion processes will be applied. Further more examples of simplified models for the description of autoignition, explosions, flame quenching and detonations will be discussed. Furthermore the main analytical methods will be illustrated using simple examples.

**Literature**

Combustion Theory, F A Williams, (2nd Edition), 1985, Benjamin Cummins.

Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation, J. Warnatz, U. Mass and R. W. Dibble, (3rd Edition), Springer-Verlag, Heidelberg, 2003.

The Mathematical Theory of Combustion and Explosions, Ya.B. Zeldovich, G.I. Barenblatt, V.B. Librovich, G.M. Makhviladze, Springer, New York and London, 1985.

## Course: Mathematical models and methods for Production Systems [2117059]

**Coordinators:** K. Furmans, J. Stoll

**Part of the modules:** Mathematic Methods (p. 57)[MSc-Modul 08, MM], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

### Learning Control / Examinations

oral

30min (electives), 60min (main subject)

examination aids: none

### Conditions

none

### Recommendations

Basic knowledge of statistic

recommended compulsory optional subject:

- Stochastics in Mecanical Engineering

recommended lecture:

- Material flow in logistic systems (also parallel)

### Learning Outcomes

Students are able to:

- Describe material flow systems with analytical solvable stochastic models,
- Derive Approches for control systems (KANBAN) based on easy models of queuing theory,
- Execute practical exercised on workstations and
- Use simulation and exakt methods.

### Content

- single server systems: M/M/1, M/G/1: priority rules, model of failures
- networks: open and closed approximations, exact solutions and approximations
- application to flexible manufacturing systems, AGV (automated guided vehicles) - systems
- modeling of control approaches like constant work in process (ConWIP) or kanban
- discrete-time modeling of queuing systems

### Media

black board, lecture notes, presentations

### Literature

Wolff: Stochastic Modeling and the Theory of Queues, Prentice Hall, 1989

Shanthikumar, Buzacott: Stochastic Models of Manufacturing Systems

**Remarks**

none

**Course: Mechanical Design I [ 2145186]****Coordinators:** A. Albers, N. Burkardt**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 4              | Winter term | en                   |

**Learning Control / Examinations**

Concomitant to the lecture a workshop with 3 workshop sessions take place over the semester. During the workshop the students were divided into groups and their mechanical design knowledge will be tested during a colloquium at the beginning of every single workshop session. The attendance is mandatory and will be controlled. The pass of the colloquia and the process of the workshop task are required for the successful participation.

Furthermore an online test is carried out.

Further information's will be announced at Ilias and at the beginning of the lecture mechanical design I.

**Conditions**

none

**Learning Outcomes**

The students are able to

- describe complex systems using the system technique.
- identify and formulate functional connections of a technical system.
- use the contact and channel approach (C&C<sup>2</sup>-A).
- chose a spring and to calculate it.
- identify different bearings and bearing arrangements and to select a suitable one for the particular situation.
- dimension bearing arrangements for different load cases.
- use the basic rules and pincipales of visualization and to create a technical drawing.
- describe the functional connections of a technical system using the C&C<sup>2</sup>-A approach and sytem theorie.

Furthermore the students can describe as a team technical solutions with a gear and draw chosen components in different technical expositions.

**Content**

Introduction in product development

Tools for visualization (technical drawing)

Product generation as a problem solving process

Technical systems for Product generation

- systems theory
- Elementary model C&C<sup>2</sup>-A

Basics of selected technical components

- springs
- bearings

Concomitant to the lectures tutorials take place with the following contents:

Gear workshop

Tutorial "tools of visualization (technical drawing)"

Tutorial "technical systems product development, sytem theory, element model C&C<sup>2</sup>-A"

Tutorial "springs"

Tutorial "bearing and bearing arrangements"

**Media**

Beamer  
Visualizer  
Mechanical components

**Literature****Lecture note:**

The lecture notes can be downloaded via the eLearning platform Ilias.

**Literature:****Konstruktionselemente des Maschinenbaus - 1 und 2**

Grundlagen der Berechnung und Gestaltung von  
Maschinenelementen;

Steinhilper, Sauer, Springer Verlag, ISBN 3-540-22033-X

or per full text access provided by university library

Grundlagen von Maschinenelementen für Antriebsaufgaben;

Steinhilper, Sauer, Springer Verlag, ISBN 3-540-29629-8

**Remarks****Lecture note:**

The Productdevelopment knowledge base PKB will be provided in digital form for registered students. All lecture notes and additional slides will be provided in Ilias.

**Course: Mechanics of laminated composites [2161983]****Coordinators:** E. Schnack**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term |                      |

**Learning Control / Examinations**

Oral examination. Duration: 30 minutes.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

In the first part of the course the students are introduced to the definition of modern composites. The terms 'lamina', 'laminae' and 'laminated' are explained in detail with reference to examples. The students are then able to classify modern composites, particularly when they use these materials to design machine structures. As by definition the material data are directionally dependent, different transformations are discussed so that the students can understand the structural behaviour and participate in the design of the materials.

**Content**

Definition of composites, definition of static and kinematic groups. Definition of material laws. Transformation of the state values of composites and transformation of the material properties for the coordinate systems in the design of machine structures.

**Literature**

Lecture notes (available in the administration office, building 10.91, rm. 310)

**Course: Mechanics and Strengths of Polymers [2173580]****Coordinators:** B. Graf von Bernstorff**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

Duration: 20 - 30 minutes

no notes

**Conditions**

basic knowledge in materials science (e.g. lecture materials science I and II)

**Learning Outcomes**

The students are prepared to

- repeat the calculus on strength and design of engineering parts exposed to complex loadings,
- estimate the influence of time and temperature on the strength of polymeric materials,
- relate the strength of materials to their molecular structure, morphology and processing parameters and
- derive failure mechanisms for homogenous polymers and composite materials therefrom.

**Content**

Molecular structure and morphology of polymers, temperature- and time dependency of mechanical behavior, viscoelasticity, time/temperature- superposition principle, yielding, crazing and fracture of polymers, failure criterions, impact and dynamic loading, corresponding principle, tough/brittle-transition, introduction to the principles of fiber reinforcement and multiple cracking in composites

**Literature**

A literature list, specific documents and partial lecture notes shall be handed out during the lecture.

## Course: Mechanics in Microtechnology [2181710]

**Coordinators:** P. Gruber, C. Greiner

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

compulsory preconditions: none

### Learning Outcomes

The students know and understand size and scaling effects in micro- and nanosystems. They understand the impact of mechanical phenomena in small dimensions. Based on this they can judge how they determine material processing as well as working principles and design of microsensors and microactuators.

### Content

1. Introduction: Application and Processing of Microsystems
2. Scaling Effects
3. Fundamentals: Stress and Strain, (anisotropic) Hooke's Law
4. Fundamentals: Mechanics of Beams and Membranes
5. Thin Film Mechanics: Origin and Role of Mechanical Stresses
6. Characterization of Mechanical Properties of Thin Films and Small Structures: Measurement of Stresses and Mechanical Parameters such as Young's Modulus and Yield Strength; Thin Film Adhesion and Stiction
7. Transduction: Piezo-resistivity, Piezo-electric Effect, Electrostatics,...
8. Aktuation: Inverse Piezo-electric Effect, Shape Memory, Elektromagnetic Actuation,...

### Literature

Folien,

1. M. Ohring: „The Materials Science of Thin Films“, Academic Press, 1992
2. L.B. Freund and S. Suresh: „Thin Film Materials“
3. M. Madou: Fundamentals of Microfabrication“, CRC Press 1997
4. M. Elwenspoek and R. Wiegerink: „Mechanical Microsensors“ Springer Verlag 2000
5. Chang Liu: Foundations of MEMS, Illinois ECE Series, 2006

## Course: Mechanical Characteristics and Microstructure Characteristics Relationships [2178120]

**Coordinators:** O. Kraft, P. Gruber

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral exam

### Conditions

None.

### Learning Outcomes

Materials are loaded by different mechanical stresses, that can lead to different reasons and forms of damage and failure. The lecture treats in detail different mechanical properties and the underlying physical mechanisms, which depend strongly on the used material (metals, ceramics, polymers, composites). A understanding of the relations between microstructure and defects and the mechanical properties shall be reached.

### Content

The following subjects are treated for the different material classes:

- plasticity
- fracture mechanics: experimental methods and analytical description of crack propagation and material behaviour at cracks
- fatigue: cyclic plasticity, riss initiation and propagation, damage analysis
- creep: time dependent plastic deformation and creep fracture

Besides the description of the material behaviour an overview of the corresponding experimental methods for mechanical characterisation will be given.

## Course: Laboratory mechatronics [2105014]

**Coordinators:** A. Albers, G. Bretthauer, C. Proppe, C. Stiller

**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

### Learning Control / Examinations

Certification of participation or oral examination depending on the "Studienplan" resp. "Prüfungs- und Studienordnung (SPO)" / IPEK: partial examination with grade

### Conditions

none

### Learning Outcomes

The student is able to ...

- use his knowledge about mechatronics and microsystems technology to solve a practical problem. The laboratory course comprises simulation, bus communication, measurement instrumentation, control engineering and programming.
- integrate the different subsystems from a manipulator to a working compound system in teamwork.

### Content

#### Part I

Control, programming and simulation of robots

CAN-Bus communication

Image processing / machine vision

Dynamic simulation of robots in ADAMS

#### Part II

Solution of a complex problem in team work

### Literature

Manuals for the laboratory course on Mechatronics

**Course: Measurement II [2138326]****Coordinators:** C. Stiller**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination

Duration: 30 minutes

no reference material

**Conditions**

Fundamentals in measurement, system and control theory, e.g. from the lecture "Measurement and Control Systems"

**Learning Outcomes**

The capabilities of modern sensor technology pave the way for novel applications in engineering. Especially digital measurement techniques may be used even in very complex environments and thus have strong impact on technological progress. Stochastic models of measurement processes form the basis for meaningful information processing and provide a valuable tool for engineering. This interdisciplinary lecture addresses students in mechanical engineering and related subjects. The lecture gives an overview of digital technology and stochastics. These areas form the basics of estimation methods that can be embedded elegantly in the theory of state observers. Applications in signal processing for modern environmental perception (video, Lidar, Radar) illustrate the discussed subjects.

**Content**

1. Amplifiers
2. Digital technology
3. Stochastic modeling for measurement applications
4. Estimation
5. Kalman Filter
6. Environmental perception

**Literature**

Various Scripts

**Course: Measurement Instrumentation Lab [2138328]****Coordinators:** C. Stiller, P. Lenz**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Colloquia

**Conditions**

Basic studies and preliminary examination; basic lectures in automatic control

**Learning Outcomes**

The laboratory complements the course "Introduction to Measurement and Control". While the course is organized into principles and subsystems, the laboratory presents complete measurement systems and methods for the most relevant industrial measurands.

**Content**

A Signal recording:

- measurement of temperature
- measurement of lengths

B Signal pre-processing:

- bridge circuits and principles of measurement
- analog/digital transducers

C Signal processing:

- measuring stochastic signals

D Complete systems:

- system identification
- inverse pendulum
- path control of a robot

**Literature**

Instructions to the experiments are available on the institute's website

**Course: Metals [2174598]**

**Coordinators:** M. Heilmaier, K. von Klinski-Wetzel  
**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Oral exam (appr. 30 min.) combined with "materials physics".

**Conditions**

Materials physics

**Learning Outcomes**

The students are familiar with the thermodynamic foundations of phase transformations, the kinetics of phase transformations in the solid state, the mechanisms of microstructure formation and microstructure-property relationships and can apply them to metallic materials. They can assess the effects of heat treatments and of alloying on the microstructure and the mechanical and physical properties of metallic materials. This competence is in particular deepened for iron- and aluminum-based alloys.

**Content**

Properties of pure elements; thermodynamic foundations of single-component and of binary systems, as well as multiphase systems; nucleation and growth; diffusion processes in crystalline materials; phase diagrams; effects of alloying; nonequilibrium microstructures; heat treatment technology

**Literature**

D.A. Porter, K. Easterling, Phase Transformation in Metals and Alloys, 2nd edition, Chapman & Hall, London 1997,  
 J. Freudenberger: <http://www.ifw-dresden.de/institutes/imw/lectures/lectures/pwe>

## Course: Methods of Signal Processing [23113]

**Coordinators:** Puente León

**Part of the modules:** Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3/1            | Winter term | de                   |

### Learning Control / Examinations

#### Conditions

None.

#### Learning Outcomes

After completing the course, students are able to:

- understand the basics of signal processing theory and describe the properties and the representation of signals.
- understand the fundamentals of time frequency analysis.
- understand the theoretical background of estimation theory and apply as well as evaluate various estimation techniques.
- apply the theoretical knowledge to practical problems.

#### Content

This lecture is offered to master students in electrical engineering and information technology who focus deeper in the field of signal processing and estimation theory.

During the last years, time frequency analysis became an important part of signal processing theory. By means of time frequency analysis, signals with variable frequency content can be analyzed. Thus, time frequency analysis and synthesis are discussed in detail. The lecture also gives an extensive overview about parameter estimation and state estimation theory.

The lecture starts with fundamentals on signal processing. The main signal properties are discussed. Signal representation in the Hilbert space is explained and different possibilities for signal representation in basis and frame are presented.

Time frequency analysis is introduced by the short time Fourier transform (STFT). The wavelet transform, its application and realization as well as another time frequency distribution – the Wigner-Ville distribution – are discussed.

The second part of the lecture is concerned with estimation theory. After fundamental considerations on signal modeling, parameter estimation techniques are introduced. Different estimators, like least squares, Gauß-Markov and so on are derived and compared. Subsequently, model based estimation and Bayes estimation is presented. The Kalman filter is discussed for state estimation.

The lecture "Methods of Signal Processing" moderates advanced knowledge in signal processing and estimation theory. The theoretical considerations are exemplified by numerous examples of real applications.

#### Literature

Uwe Kiencke, Michael Schwarz, Thomas Weickert: Signalverarbeitung - Zeit-Frequenz-Analyse und Schätzverfahren, Oldenbourg, 2008.

**Course: Analysis tools for combustion diagnostics [2134134]****Coordinators:** U. Wagner**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination, Duration: 25 min., no auxiliary means

**Conditions**

none

**Recommendations**

Fundamentals of Combustion Engines helpful

**Learning Outcomes**

The students can name and explain state-of-the-art methods to analyse the process in combustion as well as special measuring techniques such as optical and laser analysis. They are able to thermodynamically model, analyse and evaluate the engine process.

**Content**

energy balance at the engine  
 energy conversion in the combustion chamber  
 thermodynamics of the combustion process

flow velocities

flame propagation

special measurement techniques

**Literature**

Lecture notes available in the lectures

## Course: Methodical Design of Composite Structures [2114101]

**Coordinators:** O. Helms

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

written, approx. 90 min

### Conditions

Maschinenkonstruktionslehre I-III

### Recommendations

Technische Mechanik I + II

Composites für Lightweight Design

### Learning Outcomes

Students are enabled to use construction methods needed to develop composite structures. They understand an engineer's tasks and challenges in project management as well as in planning and realizing research- and development-projects.

They understand the use of composites as support structures as well as planning and designing.

### Content

- construction
- definition of task
- conception
- predimensioning
- designing composite structures
- planning composite production

### Media

**Literature:** H. Schürmann, Konstruieren mit Faser-Kunststoff-Verbunden : mit ... 39 Tabellen, 2., bearb. und erw.Aufl. ed. Berlin: Springer, 2007.

Cript: O. Helms, Methodisches Konstruieren von Faserverbund-Strukturen, is offered at lecture

**Course: Microoptics and Lithography [2142884]****Coordinators:** T. Mappes**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

oral, duration 20 minutes, aids: none

**Conditions**

Basics in optics

**Learning Outcomes****Content**

**Course: Microactuators [2142881]****Coordinators:** M. Kohl**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

(1) as core subject in the major "Actuators and Sensors" combined with the core subject "New Actuators and Sensors", oral, 60 minutes

or

(2) as optional subject, oral, 30 minutes

**Conditions**

None.

**Recommendations**

The lecture addresses students in the fields of mechanical engineering, mechatronics and information technology, materials science and engineering, electrical engineering and economic sciences. A comprehensive introduction is given in the basics and current developments on the microscopic length scale.

The lecture is core subject of the major course "Actuators and Sensors" of the specialization "Mechatronics and Microsystems Technology" in Mechanical Engineering.

Mechanical Engineering: Specialization M&M / Major 54

**Learning Outcomes**

- Knowledge of the actuation principles including pros and cons
- Knowledge of important fabrication technologies
- Explanation of layout and function of the microactuators
- Calculation of important properties (time constants, forces, displacements, etc.)
- Development of a layout based on specifications

**Content**

- Basic knowledge in the material science of the actuation principles
- Layout and design optimization
- Fabrication technologies
- Selected developments
- Applications

The lecture includes amongst others the following topics:

- Microelectromechanical systems: linear actuators, microrelais, micromotors
- Medical technology and life sciences: Microvalves, micropumps, microfluidic systems
- Microrobotics: Microgrippers, polymer actuators (smart muscle)
- Information technology: Optical switches, mirror systems, read/write heads

**Literature**

- Lecture notes
- D. Jendritza, Technischer Einsatz Neuer Aktoren: Grundlagen, Werkstoffe, Designregeln und Anwendungsbeispiele, Expert-Verlag, 3. Auflage, 2008
- M. Kohl, Shape Memory Microactuators, M. Kohl, Springer-Verlag Berlin, 2004
- N.TR. Nguyen, S.T. Wereley, Fundamentals and applications of Microfluidics, Artech House, Inc. 2002
- Y. Bar-Cohen, Electroactive Polymer (EAP) Actuators as Artificial Muscles, SPIE – The International Society for Optical Engineering, 2004

## Course: Microstructure characterization and modelling [2161251]

**Coordinators:** T. Böhlke, F. Fritzen

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral examination

### Conditions

None.

### Recommendations

This course is geared to MSc students.

### Learning Outcomes

The students can

- 
- list, apply and evaluate basic measures to describe the geometry of microstructured materials
- choose appropriate distribution functions for describing fibre or particle reinforced or polycrystalline materials
- list and evaluate the basic steps of algorithms for generation of synthetic structures

### Content

An introduction to the statistical description of geometric properties of microstructured materials is given. Typically, particle or fibre reinforced materials and polycrystalline materials are considered. The statistical description using n-point-correlation functions is described as well as characteristic measures and distribution functions (fibre or crystal orientation distribution functions) are discussed. Additionally, methods for generation of synthetic structures are considered which are typical input data for numerical multiscale simulations.

### Literature

Torquato, S.: Random heterogeneous materials: microstructure and macroscopic properties, Springer, New York, 2002.

Ohser, J., Mücklich, F.: Statistical Analysis of Microstructures in Materials Science, Statistics in Practice, John Wiley & Sons, 2000.

## Course: Modelling of Microstructures [2183702]

**Coordinators:** A. August, B. Nestler, D. Weygand

**Part of the modules:** Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Winter term | de                   |

### Learning Control / Examinations

We regularly hand out exercise sheets. The individual solutions will be corrected.

Exam: oral 30 minutes or written.

### Conditions

None.

### Recommendations

materials science  
fundamental mathematics

### Learning Outcomes

The student can

- explain the thermodynamic and statistical foundations for liquid-solid and solid-solid phase transition processes and apply them to construct phase diagrams.
- describe the specific characteristics of dendritic, eutectic and peritectic microstructures.
- explain the mechanisms of grain and phase boundary motion induced by external fields
- use the phase-field method for simulation of microstructure formation processes using modeling approaches and challenges of current research
- has experiences in computing and conduction simulations of microstructure formation from an integrated computer lab.

### Content

- Brief Introduction in thermodynamics
- Statistical interpretation of entropy
- Gibbs free energy and phase diagrams
- Free energy functional
- Phasefield equation
- Gibbs-Thomson-equation
- Driving forces
- Grand chemical potential functional and the evolution equations
- For compare: Free energy functional with driving forces

### Media

Black board and slides.

### Literature

1. Gottstein, G. (2007) Physikalische Grundlagen der Materialkunde. Springer Verlag Berlin Heidelberg

2. Kurz, W. and Fischer, D. (1998) Fundamentals of Solidification. Trans Tech Publications Ltd, Switzerland Germany UK USA
3. Porter, D.A. Eastering, K.E. and Sherif, M.Y. (2009) Phase transformation in metals and alloys (third edition). CRC Press, Taylor & Francis Group, Boca Raton, London, New York
4. Gaskell, D.R., Introduction to the thermodynamics of materials
5. Problem sheets

## Course: Mobile Machines [2114073]

**Coordinators:** M. Geimer

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Summer term | de                   |

### Learning Control / Examinations

oral examination.

### Conditions

Knowledge in Fluid Power is required.

### Recommendations

It is recommended to attend the course *Fluid Power Systems* [2114093] beforehand.

### Learning Outcomes

After completion of the course the students have knowledge of:

- a wide range of mobile machines
- operation modes and working cycles of important mobile machines
- selected subsystems and components

### Content

- Introduction of the required components and machines
- Basics of the structure of the whole system
- Practical insight in the development techniques

### Media

Lecture notes.

## Course: Model based Application Methods [2134139]

**Coordinators:** F. Kirschbaum

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term |                      |

### Learning Control / Examinations

take-home exam, short presentation with oral examination

### Conditions

none

### Recommendations

knowledge in Basics of combustion engines, vehicular systems, control theorie and statistics.

### Learning Outcomes

The student can name the most important methods for model-based calibration of powertrain ECUs. Particulary he can choose and apply the correct approach for empirical modeling for a given powertrain calibration task (fuel consumption, emissions, air path, driveability, etc.) and type of plant (linear-nonlinear, static-dynamic, etc.). He is capable to solve typical Problems of a calibration engineer of automotive OEMs or suppliers.

### Content

The efforts for the calibration of automotive powertrain ECUs are increasing due to new engine or powertrain technologies and tightening emission laws. From a present view only model based calibration methods are capable to handle this situation. The lecture presents a selection of practice-proofed model-based calibration methods.

### Media

Lecture notes, blackboard, presentations and life demonstrations via projector

**Course: Modelling and Simulation [2185227]****Coordinators:** C. Proppe, K. Furmans, B. Pritz, M. Geimer**Part of the modules:** Modeling and Simulation (p. 54)[MSc-Modul 05, MS]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 7            | 4              | Winter term | de                   |

**Learning Control / Examinations**

Master students: written exam

Seminar note by colloquium with presentation

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The student:

- has an overview of modelling and simulation techniques typical in mechanical engineering ,
- obtains the ability to carry out simulation studies starting from the formulation of problems by concepts, implementation, verification and validation,
- exercises complex simulation studies.

**Content**

Introduction: Overview, concept formation, simulation studies, time/event-discrete models, event-oriented/process orientated/transaction-oriented view, typical model classes (operation/maintenance, storekeeping, loss-susceptible systems)

Time-continuous models with concentrated parameters, model characteristics and model analysis Numerical treatment of ordinary differential equations and differential-algebraic sets of equations coupled simulations with concentrated parameters

Time-continuous models with distributed parameters, description of systems by means of partial differential equations, model reduction, numerical solution procedures for partial differential equations

**Media**

presentations

**Literature**

None.

**Remarks**

none

**Course: Modeling of Thermodynamical Processes [2167523]****Coordinators:** R. Schießl, U. Maas**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 6            | 3              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

After completing the course the students are able to:

- formulate thermodynamical basics in a mathematical scheme.
- abstract and modell complex thermodynamic processes.
- determine and implement adequate numerical schemes for the solution of the resulting systems of equations.

**Content**

Thermodynamic basics

Numerical solver strategies for algebraic equations

Optimization issues

Ordinary and partial differential equations

Application to various problems in thermodynamics (engine processes, determination of equilibrium states, unsteady processes in inhomogeneous systems)

**Literature**

Lecture notes

Numerical Recipes {C, FORTRAN}; Cambridge University Press

R.W. Hamming; Numerical Methods for scientists and engineers; Dover Books On Engineering; 2nd edition; 1973

J. Kopitz, W. Polifke; Wärmeübertragung; Pearson Studium; 1. Auflage

## Course: Modelling and Simulation [2183703]

**Coordinators:** B. Nestler, P. Gumbsch

**Part of the modules:** Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 5            | 3              | Winter / Summer Term | de                   |

### Learning Control / Examinations

We regularly hand out exercise sheets. In addition, the course will be accompanied by practical exercises at the computer.

written examination: 90 minutes

### Conditions

None.

### Recommendations

preliminary knowlegde in mathematics, physics and materials science

### Learning Outcomes

The student can

- explain the basic algorithms and numerical methods which are beside other applications relevant for materials simulations.
- describe and apply numerical solution methods for partial differential equations and dynamical systems
- apply numerical methods to solve heat and mass diffusion problems which can also be used to model microstructure formation processes
- has experiences in how to implement and program the introduced numerical methods from an integrated computer lab.

### Content

The course gives an introduction to modelling and simulation techniques.

The following topics are included:

- splines, interpolation methods, Taylor series
- finite difference method
- dynamical systems
- numerics of partial differential equations
- mass and heat diffusion
- microstructure simulation
- parallel and adaptive algorithms
- high performance computing
- practical exercises

### Media

Slides and black board. The slides will be provided as a manuscript for the course.

### Literature

1. Scientific Computing, G. Golub and J.M. Ortega (B.G.Teubner Stuttgart 1996)

**Course: [2158206]****Coordinators:** F. Schmidt**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations****Conditions**

Can not be combined with the lecture Building Simulation [2157109]

**Learning Outcomes****Content**

## Course: Modern Software Tools in Power Engineering [2199119]

**Coordinators:** T. Leibfried

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Summer term | en                   |

### Learning Control / Examinations

The examination results from the chosen module, otherwise:

Oral test at the beginning of the internship

Duration: 15-20 minutes plus discussion

Written report about the results of the experiments performed during the internship

### Conditions

none

### Recommendations

none

### Learning Outcomes

After completing the course students can:

- apply commercial software for calculating magnetic and electric field.
- apply commercial software for power grid calculations.

### Content

During this practical course students will be able to work with three power engineering software tools. Participants should individually solve three typical engineering tasks:

- **Modelling a high voltage bushing using finite element software “Maxwell”.**  
In this module students will design a high voltage transformer bushing which resists high electric field stress. Using a finite element software it is possible to determine critical values already during the design phase, before producing costly models or prototypes.
- **Development and Validation of an elevator control system based on a Siemens Simatic S7 PLC**

The PLC software Simatic S7 is a standard system for all kinds of industrial automation and control tasks. It consists of several programs which can be individually configured. During this course module students will be able to develop a control system which can be tested on a physical elevator model.

- **Load Flow Calculation of an industrial distribution grid using grid simulation software „DlG SILENT Powerfactory“**

The intention of this network analysis module is to understand the theory of load flow and short circuit calculation and to get familiar with its usage in practice. Further, an insight in real network calculation software shall be imparted.

### Media

Blackboard and Powerpoint presentation

### Literature

Course note packet

P. Kundur

“Power System Stability and Control“

McGraw-Hill Inc., 1994, ISBN 0-07-035958-X

N. G. Hingorani, L. I. Gyugyi

“Understanding FACTS“

Institute of Electrical and Electronics Engineers Inc., 2000, ISBN 0-7803-3455-8

## Course: Modern Physics for Engineers [4040311]

**Coordinators:** B. Pilawa

**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 2              | Summer term | de                   |

### Learning Control / Examinations

Written exam. The written exam is scheduled in the beginning of each semester.

Duration of Examination: 180 min.

### Conditions

Solid mathematical background, basic knowledge in physics.

### Learning Outcomes

The students

- are familiar with the basic experimental results leading to relativistic physics
- understand the principles of relativity
- comprehend the coherence of the particle and wave description of light and matter
- understand the basic principles leading to the Dirac- and Schrödinger-equation
- are able to apply the Schrödinger-equation to basic problems in quantum mechanics
- comprehend the limits of wave mechanics
- have a good understanding of the hydrogen atom
- understand the basic properties of nuclei
- know the fundamental particles and interactions

### Content

I. Introduction

II. Special relativity

III. Wave-particle duality

IV. Matter waves

V. The hydrogen atom VI. Nuclei and particles

### Literature

Paul A. Tipler: Physics for engineers and scientists

Paul A. Tipler: Modern Physics

**Course: Engine Laboratory [2134001]****Coordinators:** U. Wagner**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

written documentation of every experiment, certificate of successful attendance, no grading

**Conditions**

Fundamentals of Combustion Engines I attended

**Learning Outcomes**

The students are able to transfer their theoretical knowledge to practical problems and to perform engine tests on state-of-the-art test benches.

**Content**

5 engine experiments in up-to-date development projects

**Literature**

Description of experiments

**Course: Engine measurement techniques [2134137]****Coordinators:** S. Bernhardt**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination, Duration: 0,5 hours, no auxiliary means

**Conditions**

None.

**Recommendations**

Combustion Engines A or Fundamentals of Combustion Engines I helpful

**Learning Outcomes**

The students are able to explain the principles of modern measuring devices and are able to determine the right device for a certain measuring problem. They are able to analyse and evaluate the results.

**Content**

Students get to know state-of-the-art measurement techniques for combustion engines. In particular basic techniques for measuring engine operating parameters such as torque, speed, power and temperature.

Possible measurement errors and aberrations are discussed.

Furthermore techniques for measuring exhaust emissions, air/fuel ratio, fuel consumption as well as pressure indication for thermodynamic analysis are covered.

**Literature**

Lecture notes available in the lectures or in the 'Studentenhaus'

1. Grohe, H.: Messen an Verbrennungsmotoren
2. Bosch: Handbuch Kraftfahrzeugtechnik
3. Veröffentlichungen von Firmen aus der Meßtechnik
4. Hoffmann, Handbuch der Meßtechnik
5. Klingenberg, Automobil-Meßtechnik, Band C

## Course: Nanotechnology for Engineers and Natural Scientists [2142861]

**Coordinators:** H. Hölscher, M. Dienwiebel, S. Walheim

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The successful attendance of the lecture is controlled by a 30 minutes written examination, and a subsequent oral examination (20 min). Passing the written exam is mandatory for the participation of the oral examination. The grade result is the result of the oral exam.

### Conditions

preliminary knowledge in mathematics and physics

### Learning Outcomes

The student can

- explain the most common measurement principles of nanotechnology especially scanning probe methods and is able to use them for the characterisation of chemical and physical properties of surfaces
- describe interatomic forces and their influence on nanotechnology
- describe methods of micro- and nanofabrication and of –nanolithography
- explain simple models used in contact mechanics and nanotribology
- describe basic concepts used for nanoscale components

### Content

- 1) Introduction into nanotechnology
- 2) History of scanning probe techniques
- 3) Scanning tunneling microscopy (STM)
- 4) Atomic force microscopy (AFM)
- 5) Dynamic Modes (DFM, ncAFM, MFM, KPFM, ...)
- 6) Friction force microscopy & nanotribology
- 7) Nanolithography
- 8) Other families of the SPM family

### Literature

1. Lecture notes, slides, script
2. Scanning Probe Microscopy – Lab on a Tip: Meyer, Hug, Bennewitz, Springer (2003)

## Course: Nanotechnology with Clusterbeams [2143876]

**Coordinators:** J. Gspann

**Part of the modules:** Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

### Learning Control / Examinations

written examination

presence in more than 70% of the lectures

Duration: 1 h

aids: none

### Conditions

None.

### Learning Outcomes

Nanotechnology is presented on the basis of a technology for nano- and microstructuring by accelerated nanoparticles (clusters), mainly in view of nanomechanics.

### Content

Nanotechnology in biology

Nanosystemstechnology

Cluster beam generation, ionisation and acceleration; cluster properties

Structure generation using accelerated metal clusters

Structuring via gas cluster impact; reactive accelerated cluster erosion (RACE)

Atomic force microscopy of impact structures; nanotribology

Comparison with femtosecond laser machining (Winter term only)

Simulations; Fullerene synthesis, impact structures, visionary nanomachinery

### Literature

Foil copies with short commentaries are distributed during the lectures.

## Course: Nanotribology and -Mechanics [2181712]

**Coordinators:** M. Dienwiebel, H. Hölscher

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term | Instruction language |
|--------------|----------------|------|----------------------|
| 4            | 2              |      |                      |

### Learning Control / Examinations

presentation (40%) and oral examination (30 min, 60%)

no tools or reference materials

### Conditions

preliminary knowlegde in mathematics and physics

### Learning Outcomes

The student can

- explain the physical foundations and common models used in the field of nanotribology and nanomechanics
- describe the most important experimental methods in nanotribology
- critically evauate scientific papers on nanotribological issues with respect to their substantial quality

### Content

Part 1: Basics:

- Nanotechnology
- Forces at nanometer scale
- contact mechanics models (Hertz, JKR, DMT)
- Experimental methods (SFA, QCM, FFM)
- Prandtl-Tomlinson model
- Superlubricity
- Atomic-Scale Wear

Part 2: Topical papers

### Literature

Lecture notes, slides and copies of articles

**Course: Novel actuators and sensors [2141865]****Coordinators:** M. Kohl, M. Sommer**Part of the modules:** Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content****Literature**

- Sensoren: "Sensors Update", Volumes 1 und 2, Edited by H. Baltes, W.Göpel, J.Hesse, VCH, 1996, ISBN 3-527-29432-5
- Nanofasern: "Nanowires and Nanobelts", Volume 2: Nanowires and Nanobelts of Functional Materials, Zhong Lin Wang, 2006, Springer, ISBN 10 0-387-28706-X

**Course: Neutron physics of fusion reactors [2189473]****Coordinators:** U. Fischer**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

The aim of this lecture is to provide the neutron physics principles required for analysis of nuclear fission and fusion reactors. First of all, the basic nuclear interaction processes are presented which are important for the physical behaviour of the reactors. Next the neutron transport phenomenon in matter is described by means of the Boltzmann transport equation. Suitable mathematical solution methods are presented such as the diffusion approximation for nuclear fission reactors and the Monte Carlo method for fusion reactors. The knowledge acquired will eventually be used to solve neutron physics problems related to the design and optimization of the reactors.

**Content**

Nuclear interaction processes and energy release

Chain reaction and criticality

Neutron transport, Boltzmann equation

Diffusion approximation, Monte Carlo method

Neutronic reactor design

**Literature**

K. H. Beckurts, K. Wirtz, Neutron Physics, Springer Verlag, Berlin, Germany (1964)

W. M. Stacey, Nuclear Reactor Physics, John Wiley & Sons, Wiley-VCH, Berlin(2007)

J. Raeder (Ed.), Kontrollierte Kernfusion. Grundlagen ihrer Nutzung zur Energieversorgung, Teubner, Stuttgart (1981)

**Course: Nonlinear Continuum Mechanics [2162344]****Coordinators:** T. Böhlke**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 2              | Summer term | en                   |

**Learning Control / Examinations**

oral examination

**Conditions**

None.

**Recommendations**

This course is geared to MSc students.

**Learning Outcomes**

The students can

- derive the kinematics of finite deformations
- derive the balance laws in regular and irregular points
- discuss the principles of material theory for given examples
- evaluate the basics of finite elasticity
- discuss the basics of elasto-plasticity
- apply basic concepts of crystal plasticity to example problems

**Content**

- tensor calculus, kinematics, balance equations
- principles of material theory
- finite elasticity
- infinitesimal elasto(visco)plasticity
- exact solutions of infinitesimal plasticity
- finite elasto(visco)plasticity
- infinitesimal and finite crystal(visco)plasticity
- hardening and failure
- strain localization

**Literature**

lecture notes

Bertram, A.: Elasticity and Plasticity of Large Deformations - an Introduction. Springer 2005.

Liu, I-S.: Continuum Mechanics. Springer 2002.

Schade, H.: Tensoranalysis. Walter de Gruyter 1997.

Wriggers, P.: Nichtlineare Finite-Element-Methoden. Springer 2001.

**Course: Nuclear Fusion Technology [2189920]****Coordinators:** A. Badea**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term |                      |

**Learning Control / Examinations**

oral exam, graded, 20 min

**Conditions**

good level of knowledge in physics and mathematics

**Learning Outcomes**

The students know about the physics of fusion, the components of a fusion reactor and their functions. Also they know the technological requirements for using fusion technology for future production of electricity. The environmental impact of using commercial fusion is also addressed.

**Content**

nuclear fission & fusion  
 neutronics for fusion  
 fuel cycles, cross sections  
 gravitational, magnetic and inertial confinement  
 fusion experimental devices  
 energy balance for fusion systems; Lawson criterion and Q-factor  
 vacuum technology  
 materials for fusion reactors  
 plasma physics, confinement  
 plasma heating  
 timeline of the fusion technology  
 ITER, DEMO  
 safety and waste management

## Course: Nuclear Power and Reactor Technology [2189921]

**Coordinators:** A. Badea

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | en                   |

### Learning Control / Examinations

The examination results from the chosen module.

### Conditions

numerical methods, partial differential equations, special functions, orthogonal polynomials

### Learning Outcomes

The students will learn fundamental reactor physics, thermal-hydraulics, control, and safety.

They will also learn about future reactor systems and technological requirements of the front-end and back-end of the fuel cycle.

### Content

nuclear fission & fusion,  
 chain reactions,  
 moderation,  
 light-water reactors,  
 transport- and diffusion-equation,  
 power distributions in reactor,  
 reactor safety,  
 reactor dynamics,  
 design of nuclear reactors,  
 breeding processes,  
 nuclear power systems of generation IV

**Course: Numerical Mathematics [01874]****Coordinators:** C. Wieners, Neuß, Rieder**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Mathematic Methods (p. 57)[MSc-Modul 08, MM], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Written examination, duration 3 hours

**Conditions**

None.

**Learning Outcomes****Content****Literature****Elective literature:**

- lecture notes (N. Neuß)
- W. Dahmen/A. Reusken: Numerik für Ingenieure und Naturwissenschaftler

## Course: Numerical mechanics for industrial applications [2162298]

**Coordinators:** E. Schnack

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

### Learning Control / Examinations

Oral examination. Duration: 30 minutes.

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

Variation principles are derived in detail on the basis of the principles of virtual work. This provides students with the fundamental knowledge necessary to construct calculus of variations as a basis for numerical mechanics, and consequently derive fundamental equations for finite element methods (FEM) and boundary element methods (BEM). In the lectures, the algorithms for higher-grade finite element processes are deduced, and the numerics for boundary element methods (BEM) are derived in detail. Students will develop an understanding for Cauchy principle values, and the integration of singular integrals will be carried out. In addition, derived methods will be extended to tasks such as plasticity. Numerical mechanics I is not a requirement for Numerical mechanics II. At the end of the course students will be able to derive algorithms for FEM and BEM independently, and evaluate short codes, so that they are better able to manage industrial software.

### Content

Brief overview of finite element methods. Structure of boundary element methods (BEM). Explanation of hybrid tension methods. Higher-grade finite element processes. Non-linear FEM processes.

### Literature

Script (available in administration office, building 10.91, rm. 310).

## Course: Computational Methods in Fluid Mechanics [2157441]

**Coordinators:** F. Magagnato

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral examination

Duration: 30 minutes

No tools or reference materials may be used during the exam.

### Conditions

none

### Learning Outcomes

The students can describe the modern numerical simulation methods for fluid flows and can explain their relevance for industrial projects. They can choose appropriate boundary and initial conditions as well as turbulence models. They are qualified to explain the meaning of suitable meshes for processed examples. Convergence acceleration techniques like multi grid, implicit methods etc. as well as the applicability of these methods to parallel and vector computing can be described by the students. They can identify problems that occur during application of these methods and can discuss strategies to avoid them. The students are qualified to apply commercial codes like Fluent, Star-CD, CFX etc. as well as the research code SPARC. They can describe the differences between conventional methods (RANS) and more advanced approaches like Large Eddy Simulation (LES) and Direct Numerical Simulation (DNS).

### Content

1. Governing Equations of Fluid Dynamics
2. Discretization
3. Boundary and Initial conditions
4. Turbulence Modelling
5. Mesh Generation
6. Numerical Methods
7. LES, DNS and Lattice Gas Methods
8. Pre- and Postprocessing
9. Examples of Numerical Methods for Industrial Applications

### Media

"Powerpoint presentation", Beamer

### Literature

Ferziger, Peric: Computational Methods for Fluid Dynamics. Springer-Verlag, 1999.

Hirsch: Numerical Computation of Internal and External Flows. John Wiley & Sons Inc., 1997.

Versteg, Malalasekera: An introduction to computational fluid dynamics. The finite volume method. John Wiley & Sons Inc., 1995

## Course: Numerical Modeling of Multiphase Flows [2130934]

**Coordinators:** M. Wörner

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral examination (in German or English language)

Duration: 30 minutes

Auxiliary means: none

### Conditions

Bachelor

### Learning Outcomes

The students can describe the physical fundamentals of multiphase flows (with focus on gas-liquid flows). The students are qualified to select for multiphase flow applications in energy and process engineering appropriate numerical methods and physical models, and to thoroughly evaluate the simulation results, so as to analyze the specific advantages, disadvantages and restrictions of each method.

### Content

1. Introduction in the subject of multi-phase flows (terms and definitions, examples)
2. Physical fundamentals (dimensionless numbers, phenomenology of single bubbles, conditions at fluid interfaces, forces on a suspended particle)
3. Mathematical fundamentals (governing equations, averaging, closure problem)
4. Numerical fundamentals (discretization in space and time, truncation error and numerical diffusion)
5. Models for interpenetrating continua (homogeneous model, algebraic slip model, standard two-fluid model and its extensions)
6. Euler-Lagrange model (particle equation of motion, particle response time, one-/two-/four-way coupling)
7. Interface resolving methods (volume-of-fluid, level-set and front-capturing method)

### Literature

A brief script can be downloaded from <http://bibliothek.fzk.de/zb/berichte/FZKA6932.pdf>.

Powerpoint presentations can be downloaded after each lecture from the ILIAS system.

A list of recommended books is provided in the first lecture.

### Remarks

For some topics of the lecture exercises are provided (working on them is optional).

## Course: Numerical simulation of reacting two phase flows [2169458]

**Coordinators:** R. Koch

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral exam

Duration: approximately 30 minutes

no tools or reference materials are allowed

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

The students have the ability to:

- describe and apply the governing equations of fluid mechanics
- select and judge appropriate methods for predicting turbulent flows
- explain the procedures of numerical solver algorithms
- judge the numerical methods, on which common CFD software is based
- judge and apply different approaches to characterize sprays
- apply methods for predicting the break up of liquids
- analyse and evaluate methods and models for the calculation of multiphase flows
- describe reactive flows and the corresponding models

### Content

The course is devoted to diploma/master students and doctoral candidates of mechanical and chemical engineering. It gives an overview of the numerical methods used for CFD of single and two phase flows. The course introduces methods for reacting single and two phase flows, as they are typically found in gas turbines and piston engines operated by liquid fuel.

1. Single phase flow: Basic equations of fluid dynamics, Turbulence: DNS, LES, RANS; Finite volume methods, Numerical solvers.

2. Two phase flows: Basics of atomisation, Characterisation of sprays, Numerical prediction of droplet movement, Numerical methods for predicting of liquid disintegration (VoF, SPH), Numerical methods for secondary atomisation; Droplet evaporation

3. Reacting flows: Combustion models; Single droplet combustion, Spray combustion.

### Literature

Lecture notes

**Course: Numerical Simulation of Turbulent Flows [2154449]****Coordinators:** G. Grötzbach**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

oral;

Duration: 30 minutes

no auxiliary means

**Conditions**

None.

**Recommendations**

basics in fluid mechanics

**Learning Outcomes**

The students are qualified to describe the fundamentals of direct numerical simulation (DNS) and large eddy simulation (LES) of turbulent flows and contrast the respective properties to those of conventional turbulence modelling approaches. They can describe subgrid scale models, peculiarities of wall modelling, suitable numerical solution schemes and evaluation methods. They have obtained the knowledge required to identify the best modelling approach (among the available methods) for the problem at hand, thus being able to solve given thermal and fluid dynamical problems appropriately.

**Content**

The lecture series will introduce in following subjects of the turbulence simulation method:

- Appearance of turbulence and deduction of requirements and limits of the simulation method.
- Conservation equations for flows with heat transfer, filtering them in time or space.
- Some subgrid scale models for small scale turbulence and their physical justification.
- Peculiarities in applying boundary and initial conditions.
- Suitable numerical schemes for integration in space and time.
- Statistical and graphical methods to analyse the simulation results.
- Application examples for turbulence simulations in research and engineering

**Media**

black board, plus pictures, movies, and script in English (distributed chapter by chapter)

**Literature**

J. Piquet, *Turbulent Flows – Models and Physics*  
Springer, Berlin (2001)

G. Grötzbach, *Revisiting the Resolution Requirements for Turbulence Simulations in Nuclear Heat Transfer*.  
Nuclear Engineering & Design Vol. 241 (2011) pp. 4379-4390

P. Sagaut, C. Meneveau, *Large-eddy simulation for incompressible flows: An introduction*.  
Springer Verlag (2010)

G. Grötzbach, Script in English

## Course: Public Law I - Basic Principles [24016]

**Coordinators:** G. Sydow

**Part of the modules:** Elective Subject Economics/Law (p. 61)[MSc-Modul 12, WF WR]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The assessment consists of a written exam concerning the courses *Public Law I* [24016] and *Public Law II* [24520] (according to Section 4(2), 1 of the examination regulation).

### Conditions

None.

### Recommendations

Parallel to the lectures tutoria are offered in which legal thinking and argumentation is practised. Their attendance is strongly recommended.

During the semester, test exams to each lecture are offered with extensive coaching. During the lecture-free time, a Q-and-A-lecture is offered. Details on the homepage of the ZAR ([www.kit.edu/zar](http://www.kit.edu/zar)).

### Learning Outcomes

The students know the core principles of public law. They are acquainted with the basics of constitutional law, the fundamental rights which route governmental actions and the entire legal system, as well as possibilities of actions and instruments (especially law, administrative act, public-private contract) of the public authority. Furthermore the distinction between public and private law is clarified. Moreover, possibilities of legal protection regarding administrative behavior is addressed. Students know how to classify problems in public law and to solve (simple) administrative and constitutional cases.

### Content

The course covers core material of constitutional and administrative law. It begins with the differentiation between public and private law. In the constitutional law part, the course will concentrate on the rule of law and individual rights, especially those protecting communication and entrepreneurship. The administrative law part will explain the different legal instruments of the administration how to act (rule, order, contract, etc.) and their propositions. Also, court proceedings to sue the administrative will be discussed. Students will learn the technique how to solve (simple) administrative and constitutional cases

### Media

extensive script with cases; content structure, further information in the lectures

### Literature

tba in scriptum

### Elective literature:

tba in scriptum

## Course: Optoelectronic Components [23486 / 23487]

**Coordinators:** W. Freude

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4,5          | 2 / 1          | Summer term | en                   |

### Learning Control / Examinations

The assessment will consist of a oral exam (20 min) according to §4 (2), 1 of the examination regulation.

### Conditions

This course can not be combined with the course Optical Sources and Detectors [23462 / 23463] and/or Optical Waveguides and Fibers [23464 / 23465].

### Recommendations

Recommendations for lectures (but this is not mandatory for this course): “Electrodynamics and field calculations” or similar course on electrodynamics, “Semiconductor Devices” or similar course, “High-frequency Technology”. Minimal background required: Calculus, differential equations, Fourier transforms and p-n junction physics.

### Learning Outcomes

The students understand the components of the physical layer of optical communication systems. To this end, the students

- acquire the knowledge of operation principles and impairments of optical waveguides,
- know the basics of laser diodes, luminescence diodes and semiconductor optical amplifiers,
- understand pin-photodiodes, and
- know the systems' sensitivity limits, which are caused by optical and electrical noise.

The knowledge presented is important in comprehending the physical layer of optical communication systems. It is this very basic understanding which enables a designer to read a device's data sheet, to make most of its favourite properties, and to avoid hitting its limitations.

Learning the working principles of key components in optical communications opens the road to understand design and performance aspects of modern transmission systems. The following components are discussed>

- Light waveguides: Wave propagation, slab waveguides, strip wave-guides, integrated optical waveguides, fibre waveguides
- Light sources and amplifiers: Luminescence and laser radiation, luminescent diodes, laser diodes, stationary and dynamic behavior, semiconductor optical amplifiers
- Receivers: pin photodiodes, electronic amplifiers, noise

### Content

The course concentrates on the most basic optical communication components. Emphasis is on physical understanding, exploiting results from electromagnetic field theory, (light waveguides), solid-state physics (laser diodes, LED, and photodiodes), and communication theory (receivers, noise).

### Media

Detailed textbook-style lecture notes, and lecture slides

### Literature

- Grau, G.; Freude, W.: Optische Nachrichtentechnik, 3. Ed. Berlin: Springer-Verlag 1991. In German. Since 1997 out of print. Corrected reprint Karlsruhe 2005, available via W. F. (w.freude@kit.edu).
- Voges, E.; Petermann, K. (Eds.): Optischen Kommunikationstechnik Handbuch für Wissenschaft und Industrie. Springer-Verlag, Berlin 2002. In German
- Agrawal, G. P.: Lightwave technology. Hoboken: John Wiley & Sons 2004
- Iizuka, K.: Elements of photonics. Vol. I, especially Vol. II. Hoboken: John Wiley & Sons 2002

## Course: Intellectual Property Rights and Strategies in Industrial Companies [2147161]

**Coordinators:** F. Zacharias

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

### Learning Control / Examinations

oral exam

### Conditions

none

### Learning Outcomes

The students understand and are able to describe the basics of intellectual property, particularly with regard to the filing and obtaining of property rights. They can name the criteria of project-integrated intellectual property management and strategic patenting in innovative companies. Students are also able to describe the key regulations of the law regarding employee invention and to illustrate the challenges of intellectual properties with reference to examples.

### Content

The lecture will describe the requirements to be fulfilled and how protection is obtained for patents, design rights and trademarks, with a particular focus on Germany, Europe and the EU. Active, project-integrated intellectual property management and the use of strategic patenting by technologically oriented companies will also be discussed. Furthermore, the significance of innovations and intellectual property for both business and industry will be demonstrated using practical examples, before going on to consider the international challenges posed by intellectual property and current trends in the sector.

Within the context of licensing and infringement, insight will be provided as to the relevance of communication, professional negotiations and dispute resolution procedures, such as mediation for example. The final item on the agenda will cover those aspects of corporate law that are relevant to intellectual property.

Lecture overview:

1. Introduction to intellectual property
2. The profession of the patent attorney
3. Filing and obtaining intellectual property rights
4. Patent literature as a source of knowledge and information
5. The law regarding employee inventions
6. Active, project-integrated intellectual property management
7. Strategic patenting
8. The significance of intellectual property
9. International challenges and trends
10. Professional negotiations and dispute resolution procedures
11. Aspects of corporate law

**Course: Patent Law [24656]****Coordinators:** P. Bittner**Part of the modules:** Elective Subject Economics/Law (p. 61)[MSc-Modul 12, WF WR]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Written or oral examen.

**Conditions**

None.

**Learning Outcomes**

It is the aim of this course to provide students with knowledge in the area of patent law and the business of technical intellectual property that builds upon, and goes beyond the knowledge the students have already acquired in the general lecture of *Industrial and intellectual property law*. Students shall understand how the legal rules depend upon, and interact with, the economic background and the legislative policy in the field of technical intellectual property, particularly in the field of information and communication technologies. Students shall learn about the rules of national, European and international patent law as well as know-how protection law and to apply these legal rules in practical cases, in particular in the area of utilizing technical intellectual property through agreements and lawsuits. The conflict between the monopoly of a patent and the antitrust law policies in Europe will be reviewed with the students.

**Content**

The course deals with the subject matter of the law of technical intellectual property, in particular inventions, patents, utility models, design patents, know-how, the rights and obligations of employees as creators of technical IP, licensing, limitations and exceptions to patenting, term of protection, enforcement of the rights and defence against these in invalidation and revocation actions. The course does not merely focus on German patent law, but likewise puts European, US and international patent law into perspective. Students shall understand how the legal rules depend upon, and interact with, the economic background and the legislative policy in the field of technical intellectual property, particularly in the field of information and communication technologies. Students shall learn about the rules of national, European and international patent law as well as know-how protection law and to apply these legal rules in practical cases, in particular in the area of utilizing technical intellectual property through agreements and lawsuits. The conflict between the monopoly of a patent and the antitrust law policies in Europe will be reviewed with the students.

**Media**

transparencies

**Literature**

- Schulte, Rainer Patentgesetz Carl Heymanns Verlag, 7. Aufl. 2005 ISBN 3-452-25114-4
- Kraßer, Rudolf, Patentrecht Verlag C.H. Beck, 5. Aufl. 2004 ISBN 3-406-384552

**Elective literature:**

tba in the transparencies

**Course: Photovoltaics [23737]****Coordinators:** M. Powalla**Part of the modules:** Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Summer term |                      |

**Learning Control / Examinations**

Tutorials, written exams, alternatively oral exam.

**Conditions**

Basic knowledge of thermodynamics and solid state physics.

**Recommendations**

Complement to "Energy Systems" and "Fundamentals of Energy Technology".

**Learning Outcomes**

After the course attendants can:

- understand energy conversion in semiconductors.
- discuss emerging technological and production relevant aspects.
- capture the interaction of photovoltaic energy systems with different system components.
- quantify losses.

**Content**

- The significance of photovoltaics in national and global energy supply.
- Physical fundamentals of energy conversion.
- Photovoltaic cells (specific parameters, materials, loss assessment).
- Implementation concepts (Silicon technology, thin layer cells, concentrator cells, dye cells and organic cells).
- Modular technique and production technology.
- Photovoltaic energy systems (Components, alternative current converter, solar tracking, system design).

**Literature**

P. Würfel, Physik der Solarzellen, 2. Auflage (Spektrum Akademischer Verlag, Heidelberg, 2000)

R. Sauer, Halbleiterphysik, (Oldenburg Wissenschaftsverlag, 2009)

H.J. Lewerenz, H. Jungblut, Photovoltaik (Springer, Berlin, 1995)

H.G. Wagemann, Photovoltaik, (Vieweg, Wiesbaden, 2010)

Tom Markvart, Luis Castaner, Photovoltaics Fundamentals and Applications, (Elsevier, Oxford, 2003)

Heinrich Häberlin, Photovoltaik, (AZ Verlag, Aarau, 2007)

## Course: Physics for Engineers [2142890]

**Coordinators:** P. Gumbsch, A. Nesterov-Müller, D. Weygand

**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

written exam, 90 min

### Conditions

none

### Learning Outcomes

The student

- has the basic understanding of the physical foundations to explain the relationship between the quantum mechanical principles and the optical as well as electrical properties of materials
- can describe the fundamental experiments, which allow the illustration of these principles

### Content

#### 1) Foundations of solid state physics

- Wave particle dualism
- Tunnelling
- Schrödinger equation
- H-atom

#### 2) Electrical conductivity of solids

- solid state: periodic potentials
- Pauli Principle
- band structure
- metals, semiconductors and isolators
- p-n junction / diode

#### 3) Optics

- quantum mechanical principles of the laser
- linear optics
- non-linear optics

### Literature

- Tipler und Mosca: Physik für Wissenschaftler und Ingenieure, Elsevier, 2004
- Haken und Wolf: Atom- und Quantenphysik. Einführung in die experimentellen und theoretischen Grundlagen, 7. Aufl., Springer, 2000

## Course: Physical basics of laser technology [2181612]

**Coordinators:** J. Schneider

**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term |                      |

### Learning Control / Examinations

oral examination (30 min)

no tools or reference materials

### Conditions

Basic knowledge of physics, chemistry and material science is assumed.

It is not possible, to combine this lecture with the lecture *Laser Application in Automotive Engineering* [2182642]

### Recommendations

None.

### Learning Outcomes

The student

- 
- can explain the principles of light generation, the conditions for light amplification as well as the basic structure and function of different laser sources.
- can describe the influence of laser, material and process parameters for the most important methods of laser-based materials processing and choose laser sources suitable for specific applications.
- can illustrate the possible applications of laser sources in measurement and medicine technology
- can explain the requirements for safe handling of laser radiation and for the design of safe laser systems.

### Content

Based on the description of the physical basics about the formation and the properties of laser light the lecture goes through the different types of laser beam sources used in industry these days. The lecture focuses on the usage of lasers especially in materials engineering. Other areas like measurement technology or medical applications are also mentioned. An excursion to the laser laboratory of the Institute for Applied Materials (IAM) will be offered.

- 
- physical basics of laser technology
- laser beam sources (solid state, diode, gas, liquid and other lasers)
- beam properties, guiding and shaping
- lasers in materials processing
- lasers in measurement technology
- lasers for medical applications
- safety aspects

The lecture is complemented by a tutorial.

**Media**

lecture notes via ILIAS

**Literature**

W. T. Silfvast: Laser Fundamentals, 2008, Cambridge University Press

W. M. Steen: Laser Material Processing, 2010, Springer

**Remarks**

It is allowed to select only one of the lectures “Laser in automotive engineering” (2182642) or “Physical basics of laser technology” (2181612) during the Bachelor and Master studies.

## Course: Planning of Assembly Systems (in German) [2109034]

**Coordinators:** E. Haller

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

### Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

### Recommendations

- Knowledge of Human Factors Engineering or Production Management / Industrial Engineering useful

### Learning Outcomes

The students

- Know planning guidelines
- Know vulnerability analysis
- Are able to plan work systems (e.g. technical or organisational structuring principles, capacity planning, precedence diagram, wages system ...)
- Are able to evaluate a planning solution
- Are able to present results

### Content

1. Planning guidelines
2. Vulnerability analysis
3. Planning of work systems (technical and organisational structuring principles, capacity planning, precedence diagram, wages system ...)
4. Evaluation
5. Presentation

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- GROB, R.; HAFFNER, H.: Planungsleitlinien Arbeitsstrukturierung. Berlin, München:Siemens AG, 1982.
- GROB, R.: Erweiterte Wirtschaftlichkeits- und Nutzenrechnung. Köln: Verlag TÜV Rheinland, 1984.
- REFA - Verband für Arbeitsstudien und Betriebsorganisation (Hrsg.): Arbeitsgestaltung in der Produktion. München: Carl Hanser Verlag, 1991. (Methodenlehre der Betriebsorganisation)

## Course: PLM for Product Development in Mechatronics [2122376]

**Coordinators:** M. Eigner

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

The assessment consists of an oral exam (30 min.).

### Conditions

None.

### Learning Outcomes

Students have a basic overview about product data management and product lifecycle management.

Students know components and core functions of PLM solutions

Students can describe trends in research and practice in the environment of PLM

### Content

*Product Data Management*

*Product Lifecycle Management*

## Course: PLM in the Manufacturing Industry [2121366]

**Coordinators:** G. Meier

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral group examination, Duration 1 hour, Auxiliary Means: none

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

Students know essential aspects of PLM Processes which are exemplarily introduced with examples from Heidelberger Druckmaschinen.

Students know objects of the PLM Process and know the interconnection between CAD and PLM.

Students understand the procedure of PLM-installation in an industrial enterprise and occurring challenges concerning strategy, vendor selection and psychology.

They are able to create installation concepts for PLM systems in the scope of team exercises and explain the approaches in presentations.

### Content

A description of systematic requirement engineering is given, based on the introduction of PLM-Processes and (Multi-) Project management in the product development process. By the introduction of a PLM-Project, Objects of the PLM Process like material master, bill of material, documents and classifications are explained. Furthermore a 3D-Process chain is introduced to show the implementation of technical modifications. Finally, specific aspects of the mechatronic development are introduced.

### Literature

Lecture slides

**Course: Polymer Engineering I [2173590]****Coordinators:** P. Elsner**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20-30 Minutes

**Conditions**

None.

**Learning Outcomes**

The field of Polymer Engineering includes synthesis, material science, processing, construction, design, tool engineering, production technology, surface engineering and recycling. The aim is, to equip the students with knowledge and technical skills, and to use the material "polymer" meeting its requirements in an economical and ecological way.

The students

- are able to describe and classify polymers based on the fundamental synthesis processing techniques
- can find practical applications for state-of-the-art polymers and manufacturing technologies
- are able to apply the processing techniques, the application of polymers and polymer composites regarding to the basic principles of material science
- can describe the special mechanical, chemical and electrical properties of polymers and correlate these properties to the chemical bindings.
- can define application areas and the limitation in the use of polymers

**Content**

1. Economical aspects of polymers
2. Introduction of mechanical, chemical and electrical properties
3. Processing of polymers (introduction)
4. Material science of polymers
5. Synthesis

**Literature**

Recommended literature and selected official lecture notes are provided in the lecture

**Course: Polymer Engineering II [2174596]****Coordinators:** P. Elsner**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20-30 Minutes

**Conditions**

Polymerengineering I

**Learning Outcomes**

The field of Polymer Engineering includes synthesis, material science, processing, construction, design, tool engineering, production technology, surface engineering and recycling. The aim is, that the students gather knowledge and technical skills to use the material “polymer” meeting its requirements in an economical and ecological way.

The students

- can describe and classify different processing techniques and can exemplify mould design principles based on technical parts.
- know about practical applications and processing of polymer parts
- are able to design polymer parts according to given restrictions
- can choose appropriate polymers based on the technical requirements
- can decide how to use polymers regarding the production, economical and ecological requirements

**Content**

1. Processing of polymers
  2. Properties of polymer components
- Based on practical examples and components
- 2.1 Selection of material
  - 2.2 Component design
  - 2.3 Tool engineering
  - 2.4 Production technology
  - 2.5 Surface engineering
  - 2.6 Sustainability, recycling

**Literature**

Recommended literature and selected official lecture notes are provided in the lecture

## Course: Polymers in MEMS A: Chemistry, Synthesis and Applications [2141853]

**Coordinators:** B. Rapp  
**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The examination will be held in oral form at the end of the lecture. The lecture can be chosen as “Nebenfach” or part of a “Hauptfach”. The second lecture of the lecture series “Polymers in MEMS B – Physics, manufacturing and applications” (which is also held in winter semester) can be combined with this lecture as part of a “Hauptfach”. In summer semester, the third part of the lecture series “Polymers in MEMS C – Biopolymers, Biopolymers and applications” will be given which may be combined with lectures A and B to form a complete “Hauptfach”.

### Conditions

Bachelor (or equivalent level) students with basic knowledge in material science and chemistry. The lecture will cover all the basics required for understanding the organic chemistry so detailed previous knowledge is not required. Basic understanding of MEMS and its technologies is helpful but not mandatory.

### Learning Outcomes

The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge required for understanding what polymers are and how they are made, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.

After attending the lecture the students will be able:

- ... to understand the physico/chemical basics of organic chemistry in polymer synthesis.
- ... to state the most important polymers and polymer classes and to develop application examples for these.
- ... to state the most important polymers in MEMS.
- ... to understand the most important techniques for rapid prototyping.
- ... to state and to understand the most important resists in MEMS.
- ... to understand the chemical synthesis of polymers.

... to correctly estimate the application scope of the individual classes of polymers.

### Content

We all come in contact with numerous polymeric products in everyday life. From water bottles to packaging to the cover of the iPad, many things are made of polymers. Polymers are also important materials for modern microelectromechanical systems (MEMS) allowing cost effective mass market compatible products, e.g., in the life sciences or diagnostics. But polymers are not just cost-effective replacements for more expensive classical materials in MEMS (such as, e.g., silicon) – some polymers have intrinsic properties that make them ideal materials for sensors, actuators or templates for biology and chemistry in MEMS.

This lecture will introduce the basics of organic chemistry required for understanding what polymers are, how they are manufactured and which mechanisms are responsible for their unique properties. The lecture will highlight (in the context of MEMS but also in a wider scope) where and why polymers are applied with a strong focus on their chemical and physical properties (and on their synthesis).

Some of the topics covered are:

- What is the basic chemistry of polymers? What are monomers, what are macromolecules and how are they formed?
- How are polymers produced on industrial scale – but also on the laboratory scale? Numerous examples of how to make (commonly and lesser known) polymers will be discussed including materials such as Plexiglas.
- Why are polymers so important for biochemistry and tissue engineering?
- How do photoresists work and why do some polymers contract when exposed to light?

- What are high-performance polymers and why do they have such a wide application range, e.g., in implants?
- What polymers fuel the household 3D printing community and what materials do 3D printers such as, e.g., the RepRap work with?
- How does 3D printing and rapid prototyping work and which polymers can be employed for which techniques?
- Why does silicone always smell like vinegar and why is this material so important for modern day microfluidics? How do you built fluid-logic devices using silicone?
- How do shape memory polymers remember their shape?
- What are polymer foams and why are they not only important for heat insulation but also for organic chemistry?
- How do glues work? Why are there two-component glues, what is superglue and how can you make glue from potatoes?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.

For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu). Preregistration is not necessary.

The examination will be held in oral form at the end of the lecture. The lecture can be chosen as “Nebenfach” or part of a “Hauptfach”. The second lecture of the lecture series “Polymers in MEMS B – Physics, manufacturing and applications” (which is also held in winter semester) can be combined with this lecture as part of a “Hauptfach”. In summer semester, the third part of the lecture series “Polymers in MEMS C – Biopolymers, Biopolymers and applications” will be given which may be combined with lectures A and B to form a complete “Hauptfach”.

#### **Media**

The lecture slides will be given out as scriptum during each lecture course.

#### **Remarks**

For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu). Preregistration is not necessary.

## Course: Polymers in MEMS B: Physics, Microstructuring and Applications [2141854]

**Coordinators:** M. Worgull

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The examination will be held in oral form at the end of the lecture. The lecture can be chosen as “Nebenfach” or part of a “Hauptfach”. The second lecture of the lecture series „Polymers in MEMS A – Chemistry, synthesis and applications ” (which is also held in winter semester) can be combined with this lecture as part of a “Hauptfach”. In summer semester, the third part of the lecture series “Polymers in MEMS C – Biopolymers, Biopolymers and applications” will be given which may be combined with lectures A and B to form a complete “Hauptfach”.

### Conditions

Bachelor (or equivalent level) students with basic knowledge in material science and mechanical engineering. The lecture will cover all the basics required for understanding. Detailed knowledge of microsystem technology and its processes is helpful but not mandatory.

### Learning Outcomes

The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge required for understanding what polymers are and how they are made, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.

After attending the lecture the students will be able:

- ... to understand the properties of polymers as a consequence of their morphology.
- ... to describe the most important structuring techniques and technologies for polymers in MEMS.
- ... to understand the mathematical basis of the most important physical models for polymers.
- ... to correctly judge polymer properties and the applicability of the polymers for their industrial processability.
- ... to understand the basics of process simulation in polymer structuring.
- ... to state the most important technical thermoplasts in MEMS and to understand their properties.
- ... to correctly classify the various types of polymers, blends, composite materials.

### Content

We all come in contact with numerous polymeric products in everyday life. From water bottles to packaging to the cover of the iPad, many things are made of polymers. Polymers are also important materials for modern microelectromechanical systems (MEMS) allowing cost effective mass market compatible products, e.g., in the life sciences or diagnostics. But polymers are not just cost-effective replacements for more expensive classical materials in MEMS (such as, e.g., silicon) – some polymers have intrinsic properties that make them ideal materials for sensors, actuators or templates for biology and chemistry in MEMS.

This lecture will introduce the basics of physics and material science required for the understanding of the mechanical behavior seen from the engineers view. Micro and nanostructuring of polymers allows the fabrication of micro parts fulfilling their tasks in mostly invisible different applications. But also the fabrication of polymer parts with functional surfaces inspired from Bionics will be presented in this lesson. The lesson will give further an overview over the polymer based structuring processes and will underline the importance by a number of applications e.g. photonic structures or Lotus-like structures.

Some of the topics covered are:

- How can polymers described from the view of engineers?
- What are the differences between polymers and metals?
- Rheology of polymer melts – How does polymer melts flow?
- How can polymers be formed and demolded?

- Which structuring processes (replication) processes are available?
- How does stress influence molded parts (e.g. the deformation of a CD in a hot car)
- Shrinkage of polymers – which precision is achievable
- Gluing or welding – How can polymers be assembled?
- Simulation of replication processes
- Characterization of polymers – which properties can be measured?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.

For further details, please contact the lecturer, PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

The examination will be held in oral form at the end of the lecture. The lecture can be chosen as “Nebenfach” or part of a “Hauptfach”. The second lecture of the lecture series “Polymers in MEMS A – Chemistry, synthesis and applications” (which is also held in winter semester) can be combined with this lecture as part of a “Hauptfach”. In summer semester, the third part of the lecture series “Polymers in MEMS C – Biopolymers, Biopolymers and applications” will be given which may be combined with lectures A and B to form a complete “Hauptfach”.

#### **Media**

The lecture slides will be given out as scriptum during each lecture course.

#### **Remarks**

For further details, please contact the lecturer, PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

**Course: Power Electronics [2199102]****Coordinators:** A. Kloenne**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | en                   |

**Learning Control / Examinations**

written examination

**Conditions**Fundamentals of Electrical Engineering,  
Fundamentals of Electronics**Learning Outcomes**

The students

- have profound knowledge about power electronic switches, their application and protection
- possess key skills in of generic power electronic circuits
- are able to analyse and calculate fundamental switched-power supplies
- understand Line-Frequency Phase Controlled Rectifiers and Inverters
- are endowed with practical converter design considerations
- are able to implement the basic control strategies in power electronic systems

**Content**

- Introduction to Power Electronics
- Overview of Power Semiconductor Switches (Diodes, Thyristors, GTO, BJT, Mosfet)
- Drive and Snubber Circuits
- Structure of Power Module Packages
- Heat Transfer of Power Semiconductors
- DC-DC Switch-Mode Converters (Step-Down Converter, Step-Up Converter, Buck-Boost Converter, Flyback Converter)
- Line-Frequency Phase-Controlled Rectifiers and Inverters (Single-Phase, Three-Phase)
- High Voltage DC Transmission
- Switch-Mode Inverters (Single Phase, Three Phase)
- Concepts of Current Control in Swicht-Mode Inverters
- Variable Freqency Inverters

**Literature**

Prof. Kloenne, Lecture Notes, Summer Semester 2013

Mohan, N.; Undeland, T.M.; Robbins, W.P.: Power Electronics, Converters, Applications and Design; Wiley, 1989

**Course: Laboratory “Laser Materials Processing” [2183640]****Coordinators:** J. Schneider, W. Pfleging**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 3              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

The assessment consists of an colloquium for every single experiment and an overall final colloquium incl. an oral presentation of 20 min.

**Conditions**

Basic knowledge of physics, chemistry and material science is assumed.

**Recommendations**

The attendance to one of the courses Physical Basics of Laser Technology (2181612) or Laser Application in Automotive Engineering (2182642) is strongly recommended.

**Learning Outcomes**

The student

- can describe the influence of laser, material and process parameters and can choose suitable parameters for the most important methods of laser-based processing in automotive engineering.
- can explain the requirements for safe handling of laser radiation and for the design of safe laser systems.

**Content**

The laboratory comprises 8 half-day experiments, which address the following laser processing topics of metals, ceramics and polymers:

- safety aspects
- surface hardening and remelting
- melt and reactive cutting
- surface modification by dispersing or alloying
- welding
- surface texturing
- metrology

There are used CO<sub>2</sub>-, excimer-, Nd:YAG- and high power diode-laser sources within the laboratory.

**Media**

lecture notes via ILIAS

**Literature**

W.T. Silfvast: Laser Fundamentals, 2008, Cambrigde University Press

W.M. Steen: Laser Materials Processing, 2010, Springer

**Remarks**

The maximum number of students is 12 per semester.

## Course: Introduction to Microsystem Technology - Practical Course [2143875]

**Coordinators:** A. Last

**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

### Learning Control / Examinations

non-graded: preparation of the experiments

graded (together with the lecture MST I resp. II): 50% questions concerning the practical training in the written 2h-exam of the lecture 'Grundlagen der Mikrosystemtechnik I resp. II'

### Conditions

pre-condition: attendance of the lecture 'Grundlagen der Mikrosystemtechnik I bzw. II'

### Learning Outcomes

- Deepening of the contents of the lecture MST I resp. II
- Understanding the technological processes in the micro system technology
- Experience in lab-work at real workplaces where normally research is carried out

### Content

In the practical training includes nine experiments:

1. Hot embossing of plastics micro structures
2. Micro electroforming
3. Mikro optics: „LIGA-micro spectrometer“
4. UV-lithography
5. Optical waveguides
6. Capillary electrophoresis on a chip
7. SAW gas sensor
8. Metrology
9. Atomic force microscopy

Each student takes part in only five experiments.

The experiments are carried out at real workstations at the IMT and coached by IMT-staff.

## Course: Product Lifecycle Management [2121350]

**Coordinators:** J. Ovtcharova

**Part of the modules:** Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

### Learning Control / Examinations

written examination

Duration:

1,5 hours

Auxiliary Means: none

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

The students can:

- clarify the management concept of PLM, its objectives and highlight the economic benefits of the PLM concept.
- illustrate the need for an integrated and cross-departmental business process - from planning, portfolio construction and return of customer information, from the use phase to maintenance and recycling of products.
- reason the processes and functions needed to support the entire product life cycle and discuss the main operating software systems (PDM, ERP, SCM, CRM) and their functions for supporting PLM.
- argue a method to successfully introduce the concept of Management PLM in companys.

### Content

Product Lifecycle Management (PLM) is an approach to the holistic and cross-company management and control of all product-related processes and data throughout the life cycle along the extended supply chain - from design and production to sales, to the dismantling and recycling.

Product Lifecycle Management is a comprehensive approach for effective and efficient design of the product life cycle. Based on all product information, which comes up across the entire value chain and across multiple partners, processes, methods and tools are made available to provide the right information at the right time, quality and the right place.

The course covers:

- A consistent description of all business processes that occur during the product life cycle (development, production, sales, dismantling, ...)
- the presentation of methods for the performance of the PLM business processes,
- explaining the most important corporate information systems to support the life cycle (PDM, ERP, SCM, CRM systems) to sample the software manufacturer SAP

### Literature

Lecture slides.

V. Arnold et al: Product Lifecycle Management beherrschen, Springer-Verlag, Heidelberg, 2005.

J. Stark: Product Lifecycle Management, 21st Century Paradigm for Product Realisation, Springer-Verlag, London, 2006.

A. W. Scheer et al: Prozessorientiertes Product Lifecycle Management, Springer-Verlag, Berlin, 2006.

J. Schöttner: Produktdatenmanagement in der Fertigungsindustrie, Hanser-Verlag, München, 1999.

M.Eigner, R. Stelzer: Produktdaten Management-Systeme, Springer-Verlag, Berlin, 2001.

G. Hartmann: Product Lifecycle Management with SAP, Galileo press, 2007.

K. Obermann: CAD/CAM/PLM-Handbuch, 2004.

**Course: Product, Process and Resource Integration in the Automotive Industry [2123364]****Coordinators:** S. Mbang**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination, Durations: 20 min, Auxiliary Means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

A considerable aspect of this lecture is to combine engineering knowledge with the practical, real industrial problems and applications.

Thus, the objectives of the lecture are:

- collaborative drafting of industrial and academic state of the art regarding the basics.
- specification of exigencies, requirements and concepts for an integrated CAx-process chain,
- introduction in the paradigms of the integrated process-oriented product development
- to convey practical industrial knowledge about the integrated product development in the automotive sector

**Content**

The lecture

- Overview of product development in the automotive sector (process- and work cycle, IT-Systems)
- Integrated product models in the automotive industry (product, process and resource)
- New CAx modeling methods (intelligent feature technology, templates & functional modeling)
- Automation and knowledge-based mechanism for product design and production planning
- Product development in accordance with defined process and requirement (3D-master principle, tolerance models)
- Concurrent Engineering, shared working
- Enhanced concepts: the digital and virtual factory (application of virtual technologies and methods in the product development)
- Systems: CAD/CAM modeling (CATIA V5), planning (CATIA/DELMIA), archiving – PDM (CATIA/SmarTeam).

Additionally, A practical industrial project study is offered, which is based on an integrated application scenario (from design of production resources, over testing and validation method planning to the manufacturing and implementation of the production resources).

Since the student will be divided in small teams, this study will also teach the students about team work and distributed development.

**Literature**

Lecture slides

**Remarks**

Max. 20 students, registration necessary (ILIAS)

## Course: Product Development - Methods of Product Development [2146176]

**Coordinators:** A. Albers, N. Burkardt, Dipl.-Ing. N. Burkardt

**Part of the modules:** Product Development (p. 55)[MSc-Modul 06, PE]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Summer term | de                   |

### Learning Control / Examinations

Written exam

Duration: 150 minutes

Auxiliaries:

- Calculator
- German dictionary (books only)

### Conditions

None.

### Learning Outcomes

The students are able to ...

- differentiate between different types of product development.
- name the relevant influencing factors of a market for product development.
- name, compare and use the central methods and process models of product development within moderate complex technical systems.
- explain problem solving techniques and associated development methods.
- explain product profiles and to differentiate and choose suitable creative techniques of solution finding on this basis.
- use design guidelines to create simple technical systems and to explain these guidelines.
- name and compare quality assurance methods; to choose and use suitable methods for particular applications.
- explain the different methods of design of experiment.
- explain the costs in development process.

### Content

Basics of Product Development: Basic Terms, Classification of the Product

Development into the industrial environment, generation of costs / responsibility for costs

Concept Development: List of demands / Abstraction of the Problem Definition / Creativity Techniques / Evaluation and selection of solutions

Drafting : Prevailing basic rules of Design / Design Principles as a problem oriented accessory

Rationalization within the Product Development: Basics of Development

Management/ Simultaneous Engineering and Integrated Product Development/Development of Product

Lines and Modular Construction Systems

Quality Assurance in early Development Phases : Methods of Quality Assurance in an overview/QFD/FMEA

### Literature

Lecture documents

Pahl, Beitz: Konstruktionslehre, Springer-Verlag 1997

Hering, Triemel, Blank: Qualitätssicherung für Ingenieure; VDI-Verlag, 1993

### Remarks

This lecture is the basis for the main subject Integrated Product Development, which is offered as a specialisation.

## Course: Product Development - Manufacturing and Material Technology [2150510]

**Coordinators:** V. Schulze, F. Zanger

**Part of the modules:** Product Development (p. 55)[MSc-Modul 06, PE]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 9            | 6              | Summer term | de                   |

### Learning Control / Examinations

The assessment is carried out as a written exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None

### Recommendations

None

### Learning Outcomes

The students . . .

- are able to use analytical calculation methods to design components subjected to simple and superposed basic loadings in quasi-static and cyclic case considering the basic principles of dimensioning.
- are capable of identifying the kinds of loading resulting from boundary conditions and external loads on a component for simple cases and can dimension it respectively.
- can distinguish more complex loading scenarios appearing in technical praxis.
- are capable of finding appropriate materials for application under consideration of technical and economical frame conditions using the basics of materials selection.
- are able to describe the application area and procedures of component dimensioning according to the guideline of Forschungskuratorium Maschinenbau e.V. and can state analogies and differences to dimensioning without guidelines.
- are capable to depict the general function of manufacturing processes and are able to assign manufacturing processes to the specific main groups.
- are enabled to identify correlations between different processes and to select a process depending on possible applications.
- are qualified to evaluate different processes regarding specific applications based on technical and economic aspects.
- have the ability to make a material and process selection with the CES Edupack and to evaluate the results.

### Content

Target of the lecture is to integrate the material and manufacturing technology into the product engineering process, to execute a component dimensioning, to give an oversight over the procedures of the manufacturing technology and to execute a material and process selection under given basic conditions. Within the lecture the basic principles of dimensioning, as well as different basic loads introduced and evaluated. To deepen the process knowledge of the well-established manufacturing procedures basics of manufacturing technology are imparted and the manufacturing procedures are discussed corresponding to their main groups considering technical as well as economic aspects. The lecture is complemented by the topic of the material and process selection. For this purpose methods are introduced, which enable a systematic material and process selection. These methods are clarified by practical examples with the aid of a software.

The content in detail is:

- basic load cases
- superposed load cases

- notch effects
- fatigue of materials
- assessment of cracked components
- endurance strength and residual stress
- primary shaping
- forming
- cutting
- joining
- coating
- heat- and surface treatment
- process selection
- CES-Edupack

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

## Course: Production Management I [2109028]

**Coordinators:** P. Stock

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Compulsory Core Subject:** oral exam

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exams are only offered in German!

### Conditions

None.

### Recommendations

- Willingness to learn interdisciplinarily (Technique, Economy, Legal regulations, Informatics . . .)

### Learning Outcomes

After completion this lecture, the students are able

- to describe the goals of production and production management,
- to describe the prevailing requirements of the working world and the thereof resulting fields of application of Production Management and to give examples,
- to describe and to apply basic theories, methods and tools for the different fields of application of Production Management on a strategical, tactical and operational level,
- to plan and control the industrial process of production and adding value,
- to evaluate the applied methods and tools of production management within a specific enterprise and to drive alternatives for organising and configuration a production system.

### Content

1. Introduction
2. Strategy of enterprises
3. Product development and programme planning
4. Location planning
5. Enterprise system (Production system, fabric planning, departmental and process organisation)
6. Management of resources (personnel, machines, material)
7. Operations planning and control
8. Controlling
9. Management systems

### Literature

Handout and literature online ILIAS.

## Course: Production Management II [2110028]

**Coordinators:** P. Stock

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

### Conditions

None.

### Recommendations

- Willingness to learn interdisciplinarily (Technique, Economy, Legal regulations, Informatics . . .)
- Knowledge of the lecture "Production Management I" (2109028) is compulsory

### Learning Outcomes

After completion this lecture, the students are able

- to describe the actual trends of production management and their influence upon an enterprise,
- to identify interfaces to adjacent disciplines (e.g. business economics, computer science, political economics),
- to describe and to apply specific theories, methods and tools of Production Management (e.g. Kanban, Heijunka, Total Quality Management)
- to evaluate production systems and the applied methods, to identify problems in a production system and to organise and configure a production system,
- to evaluate the applied methods and tools of production management within a specific enterprise and to drive alternatives for organising and configuration a production system.

### Content

The lecture presents selected methods of Production Management.

### Literature

Handout and literature online ILIAS.

## Course: Production Planning and Control [2110032]

**Coordinators:** A. Rinn

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

### Conditions

- Compact course
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

### Recommendations

- Knowledge in Production Management (resp. Industrial Engineering) is necessary
- Knowledge of Work Science and Economics is usefull
- Knowledge of Informatics is not required, but usefull

### Learning Outcomes

- Get deeper insights within production management
- Increase knowledge of production planning and control
- Understand basic techniques for the modelling and simulation of production systems

### Content

1. Goals and recomanditions for production planning and control
2. Strategies for work control
3. Case study: Manufacturing of bicycles
4. FASI-Plus: Simulation of a bicycle factory for the production planning and control
5. Simulation of the order processing
6. Decision making about order control and procurement of purchased parts
7. Evaluation of the simulation protocols
8. Realisation of production planning and control

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- KOŠTURIÁK, Ján; GREGOR, Milan: Simulation von Produktionssystemen. Wien, New York: Springer, 1995.

- LIEBL, Franz: Simulation. München, Wien: Oldenbourg, 2. Auflage 1995.
- VDI 3633, Blatt 6: Simulation von Logistik-, Materialfluss- und Produktionssystemen – Abbildung des Personals in Simulationsmodellen. Berlin: Beuth-Verlag, 2001.
- VDI 4499, Blatt 1: Digitale Fabrik - Grundlagen. Berlin: Beuth-Verlag, 2008.

Please refer to the latest edition.

## Course: Production Techniques Laboratory [2110678]

**Coordinators:** K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL  
**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

### Learning Control / Examinations

**Advanced Internship:** Participate in practice exercise courses and complete the colloquia successfully.

**Elective Subject:** Participate in practice exercise courses and complete the colloquia successfully and presentation of a specific topic.

**Optional Subject:** Participate in practice exercise courses and complete the colloquia successfully and presentation of a specific topic.

### Conditions

None.

### Recommendations

Participation in the following lectures:

- Informationssysteme in logistics and supply chain management
- Material flow in logistic systems
- Manufacturing technology
- Human Factors Engineering

### Learning Outcomes

*The students acquire in the lab profound knowledge about the scientific theories, principles and methods of Production Engineering. Afterwards they are able to evaluate and design complex production systems according to problems of manufacturing and process technologies, materials handling, handling techniques, information engineering as well as production organisation and management.*

*After completion this lab, the students are able*

- *to analyse and solve planning and layout problems of the discussed fields,*
- *to evaluate and configure the quality and efficiency of production, processes and products,*
- *to plan, control and evaluate the production of a production enterprise,*
- *to configure and evaluate the IT architecture of a production enterprise,*
- *to design and evaluate appropriate techniques for conveying, handling and picking within a production system,*
- *to design and evaluate the part production and assembly respective to processes and work places.*

### Content

The production technique laboratory (PTL) is a collaboration of the institutes wbk, IFL, IMI and ifab.

1. Computer Aided Product Development (IMI)
2. Computer communication in factory (IMI)
3. Production of parts with CNC turning machines (wbk)
4. Controlling of production systems using PLCs (wbk)
5. Automated assembly systems (wbk)
6. Optical identification in production and logistics (IFL)

7. RFID identification systems (IFL)
8. Storage and order-picking systems (IFL)
9. Configuration of Display Work Stations (ifab)
10. Time study (ifab)
11. Workplace configuration (ifab)

**Media**

several

**Literature**

Handout and literature online ILIAS.

**Remarks**

none

## Course: Productivity Management in Production Systems [2110046]

**Coordinators:** S. Stowasser

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

### Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

### Recommendations

- Knowledge of work science is usefull

### Learning Outcomes

- Ability to design work operations and processes effectivly and efficiently
- Instruction in methods of time study (MTM, Data acquisition etc.)
- Instruction in methods and principles of process design
- The Students are able to apply methods for the design of workplaces, work operations and processes.
- The Students are able to apply actual approaches of process and production organisation.

### Content

1. Definition and terminology of process design and industrial engineering
2. Tasks of industrial engineering
3. Actual approaches of organisation of production (Holistic production systems, Guided group work et al.)
4. Methods and principles of industrial engineering and production systems
5. Case studies and exercises for process design

### Media

Powerpoint, movies, exercises

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- BASZENSKI, Norbert: Methodensammlung zur Unternehmensprozessoptimierung. Köln: Wirtschaftsverlag Bachem, 3. Auflage 2008.

- BOKRANZ, Rainer; LANDAU, Kurt: Produktivitätsmanagement von Arbeitssystemen. Stuttgart: Schäffer Poeschel, 2006.
- Themenheft: Methodisches Produktivitätsmanagement: Umsetzung und Perspektiven. In: Zeitschrift angewandte Arbeitswissenschaft, Köln, 204(2010).
- NEUHAUS, Ralf: Produktionssysteme: Aufbau - Umsetzung - betriebliche Lösungen. Köln: Wirtschaftsverlag Bachem, 2008.
- ROTHER, Mike; SHOOK, John: Sehen lernen - mit Wertstromdesign die Wertschöpfung erhöhen und Verschwendung beseitigen. Aachen: Lean Management Institut, 2004.

Please refer to the latest edition.

## Course: Project Workshop: Automotive Engineering [2115817]

**Coordinators:** F. Gauterin

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 6            | 3              | Winter / Summer Term | de                   |

### Learning Control / Examinations

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

### Conditions

None.

### Learning Outcomes

The students are familiar with typical industrial development processes and working style. They are able to apply knowledge gained at the university to a practical task. They are able to analyze and to judge complex relations. They are ready to work self-dependently, to apply different development methods and to work on approaches to solve a problem, to develop practice-oriented products or processes.

### Content

During the Project Workshop Automotive Engineering a team of six persons will work on a task given by an German industrial partner using the instruments of project management. The task is relevant for the actual business and the results are intended to be industrialized after the completion of the project workshop.

The team will generate approaches in its own responsibility and will develop solutions for practical application. Coaching will be supplied by both, company and institute.

At the beginning in a start-up meeting goals and structure of the project will be specified. During the project workshop there will be weekly team meetings. Also a milestone meeting will be held together with persons from the industrial company. In a final presentation the project results will be presented to the company management and to institute representatives.

### Literature

Steinle, Claus; Bruch, Heike; Lawa, Dieter (Hrsg.), Projektmanagement, Instrument moderner Innovation, FAZ Verlag, Frankfurt a. M., 2001, ISBN 978-3929368277

The scripts will be supplied in the start-up meeting.

## Course: Project Mikro Manufacturing: Design and Manufacturing of Micro Systems [2149680]

**Coordinators:** V. Schulze, P. Hoppen

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | de                   |

### Learning Control / Examinations

The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None

### Recommendations

Knowledge of CAD tools is favorable but not necessary. Previous knowledge of manufacturing is reasonable.

### Learning Outcomes

The students . . .

- are able to describe the micro manufacturing processes as well as their characteristics and applications.
- can choose suitable manufacturing processes for a given product.
- are able to describe the process along the CAD-CAM process chain from scratch to manufacturing.
- can explain how the development process for a micro product looks like.
- are able to describe how design for manufacturability works for micro products and where the differences to macroscopic scale are.

### Content

The course „Project micro manufacturing: design and manufacturing of a micro system“ combines the basics of micro manufacturing with project work. The project work will be done in cooperation with an industry partner. The students learn the basics of micro milling, micro electric discharge machining, micro laser ablation, micro powder injection molding and micro quality assurance. Furthermore they get to know the CAD-CAM process chain. That is the manufacturing of a production out of a CAD model. The students develop ideas and concepts matching the given task and present the results to the industry partner. Then they create parts that are designed for manufacturability out of their concepts. Those parts are manufactured at the wbk and finally assembled to a prototype. In winter semester 2012/13 innovative couplings for model railways were developed and functional prototypes were built.

### Media

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

### Literature

Lecture Notes

### Remarks

None

## Course: Development of Oil-Hydraulic Powertrain Systems [2113072]

**Coordinators:** G. Geerling, I. Ays

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral examination

### Conditions

knowledge in the fluidics

### Learning Outcomes

The students are able to understand hydraulic systems und to develop them independently. They apply their competences in a simulation of a development project with real hydraulic components within a laboratory tutorial.

### Content

The bloc course offered by the Chair of Mobile Machines (Mobima) conveys the basics of planning and development of mobile and industrial hydrostatic systems. The lecturer works for a market leading company producing fluid power drives and controls and gives a deep view into the process of planning and development using real life examples. The contents of the course are:

- marketing, project planning
- hydrostatic circuits
- heat balance, hydraulic accumulators
- filtration, noise lowering
- development exercises + laboratory tutorial

## Course: Project Management in Rail Industry [2115995]

**Coordinators:** P. Gratzfeld

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

### Conditions

None

### Recommendations

None

### Learning Outcomes

The students learn the basic of project management.

They learn about the roles of project manager and project core team.

They understand the project phases and know about processes and tools.

They understand the governance process behind.

### Content

Rail vehicles are capital-intensive goods which are manufactured in small series (like aircraft). The work to done at industry and customers is organized in "projects". This is completely different to the way of working in large-scale production (like car industry). Everybody working in this type of business is part of a project and should be aware of the typical processes.

The lecturer provides a comprehensive overview about modern project management for small series of capital-intensive goods.

The content is not only valid for rail vehicles but also other areas.

The following topics will be discussed:

Introduction: definition of project and project management

Project management system: project phases, main processes and supporting processes, governance

Organization: organizational structure within a company, project organization, roles in a project organization

Main processes: project start, project plan, work brake down structure, detailed project schedule, risk and opportunity management, change management, project closure

Governance

### Media

All slides are available for download (Ilias-platform).

### Literature

A bibliography is available for download (Ilias-platform).

### Remarks

None.

**Course: Project management in Global Product Engineering Structures [2145182]****Coordinators:** P. Gutzmer**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 minutes

Auxiliary means: none

**Conditions**

none

**Learning Outcomes**

Project management is essential for successful companies.

The students are able to describe, explain and compare characteristics and attributes of product development processes based on practical examples of industry.

They are able to specify processes of product development, their necessary organization structures and important attributes.

The participants learn to identify and evaluate aspects of product management within international operating companies.

**Content**

Product development process

Coordination of product development and handling of complexity

project management

matrix organization

planning / specification / target system

interaction of development and production

**Literature**

lecture notes

## Course: Process Simulation in Forming Operations [2161501]

**Coordinators:** D. Helm

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term |                      |

### Learning Control / Examinations

oral examination (30 min)

### Conditions

None.

### Learning Outcomes

The students can

- describe and classify the most important forming methods
- explain the reasons for the die Ursachen für die gute Umformbarkeit von Metallen in Bezug zu den stattfindenden Phänomenen in der Mikrostruktur erläutern und den Bezug zu den Abläufen in den unterschiedlichen Fertigungsverfahren herstellen
- describe the kinematics of infinitesimal and finite deformations
- explain the differences between different stress tensors in case of finite deformations
- apply simple material models of elasticity and plasticity and explain their operation
- derive the equation of the finite element method based on the balance laws
- describe why the material models are necessary and how they are applied in the whole algorithm
- sketch the process of a FEM-simulation and give the relation to the theoretical basis

### Content

Based on basics of continuum mechanics, material theory and numerics the lecture gives an introduction into the simulation of forming operations for metals

- plasticity for metallic materials: dislocations, twinning, phase transformations, anisotropy, hardening
- classification of forming operations and discussion of selected topics
- basics of tensor algebra and tensor analysis
- continuum mechanics: kinematics, finite deformations, balance laws, thermodynamics
- material theory: basics, modelling concepts, plasticity and visco plasticity, yield functions (von Mises, Hill, ...), kinematic and isotropic hardening, damage
- thermomechanical coupling
- modelling of contact
- finite element method: explicit and implicate formulations, types of elements, numerical integration of material models
- process simulation of selected problems of sheet metal forming

**Course: Advanced powder metals [2126749]****Coordinators:** R. Oberacker**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (20-30 min) taking place at the agreed date. The re-examination is offered upon agreement.

**Conditions**

None.

**Recommendations**

Knowledge of basic material science is assumed.

**Learning Outcomes**

The students know the basics of powder metallurgy. They are able to assess the conditions for applying either powder metallurgy or competing production methods. They have knowledge on production, properties and application of the most important PM materials.

**Content**

The lecture gives an overview on production, properties and application structural and functional powder metallurgy material. The following groups of materials are presented: PM High Speed Steels, Cemented Carbides, PM Metal Matrix Composites, PM Specialties, PM Soft Magnetic and Hard Magnetic Materials.

**Literature**

- W. Schatt ; K.-P. Wieters ; B. Kieback. „Pulvermetallurgie: Technologien und Werkstoffe“, Springer, 2007
- R.M. German. “Powder metallurgy and particulate materials processing. Metal Powder Industries Federation, 2005
- F. Thümmel, R. Oberacker. “Introduction to Powder Metallurgy”, Institute of Materials, 1993

## Course: Quality Management [2149667]

**Coordinators:** G. Lanza

**Part of the modules:** Elective Subject Economics/Law (p. 61)[MSc-Modul 12, WF WR], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Supplementary Subject, Elective Subject Economics/Law:** The assessment is carried out as a written exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

**Elective Subject:** The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None

### Recommendations

None

### Learning Outcomes

The students . . .

- are capable to comment on the content covered by the lecture.
- are capable of substantially quality philosophies.
- are able to apply the QM tools and methods they have learned about in the lecture to new problems from the context of the lecture.
- are able to analyze and evaluate the suitability of the methods, procedures and techniques they have learned about in the lecture for a specific problem.

### Content

Based on the quality philosophies Total Quality Management (TQM) and Six Sigma, the lecture deals with the requirements of modern quality management. Within this context, the process concept of a modern enterprise and the process-specific fields of application of quality assurance methods are presented. The lecture covers the current state of the art in preventive and non-preventive quality management methods in addition to manufacturing metrology, statistical methods and service-related quality management. The content is completed with the presentation of certification possibilities and legal quality aspects.

Main topics of the lecture:

- The term "quality"
- Total Quality Management (TQM) and Six Sigma
- Universal methods and tools
- QM during early product stages – product definition
- QM during product development and in procurement
- QM in production – manufacturing metrology
- QM in production – statistical methods
- QM in service
- Quality management systems
- Legal aspects of QM

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

**Course: Range Extender [2146440]****Coordinators:** H. Bauer**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 2              | Winter term | en                   |

**Learning Control / Examinations**

oral/written examination

**Conditions**

a subset of: thermodynamics, fluid mechanics, turbo machinery, combustion, rotor dynamics, power electronics, electric machines, machine elements, mechanical design and project management

**Learning Outcomes**

The students will be trained to work in an interdisciplinary team. Besides technical knowledge they will learn how to organise and run a project in a controlled manner within a given time frame and to a certain degree also within a limited budget.

**Content**

In a range extender an internal combustion engine (e.g. an SI/Diesel engine or a micro gas turbine) significantly extends the range of a normally electrically driven vehicle such as a car, a van, a truck or a bus. The internal combustion engine charges the battery of the electric vehicle only rather than to drive the vehicle directly. Hence the range extender additionally comprises an electric generator and some power electronics components.

The envisaged project focuses on a micro gas turbine as the internal combustion engine which drives an ultra-high-speed electric generator. Micro gas turbine and generator will be optimised for the design point only. As two completely different engines mechanically connected to each other will be subject of the course, i.e. a micro gas turbine and an electric generator, the task to preliminarily design a range extender will be strongly interdisciplinary. It will be solved by establishing a team consisting of students having specialised knowledge from different disciplines such as turbomachinery, combustion, rotor dynamics, electric engines and power electronics.

In an introductory lesson the boundary conditions for the range extender will be given, such as size of the vehicle and its typical operational range and profile. A team will be formed with specific roles such as project manager, team leader(s) and specialists based on the needs of the project and the individual skills of the team members. Regular internal meetings as well as external review meetings will be agreed.

The expected result of the project will be a preliminary design of the major components of the range extender in terms of 3D CAD models, a cost estimate as well as a potential market share taking into account competing concepts. The range extender design will be presented to an external audience including the lecturers as well as industrial representatives.

**Course: Reactor Safety I: Fundamentals [2189465]****Coordinators:** V. Sánchez-Espinoza**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

- Knowledge of fundamentals of nuclear safety (technology, atomic law, principles)
- Gain understanding of safety features and systems of a nuclear power plant
- Ability to understand the interactions of different areas e.g. thermal hydraulics, neutronics, materials, human factors, organisation and management of a nuclear power plant

**Content**

The goal of the lecture is to impart the fundamentals of nuclear safety that is needed to assess the safety of nuclear facilities. Nuclear safety is inherently of multidisciplinary character and is based on the following pillars: technology, man, organisation and measures; all together named "Safety Culture". The nuclear facilities, coal-fired power plants, aerospace industry and gen technology for example are connected with a certain risk for the environment and society. Consequently, the erection and operation of nuclear installations needs must undergo a licensing process and a continuous surveillance by the regulatory body. This lecture will be concentrated on the following topics:

- Historical development of nuclear safety
- Risk evaluation for nuclear power plants compared to other technologies
- Scope, principles and structure of the atomic Law (national and international context)
- Fundamentals of nuclear safety
- Safety features and systems of nuclear power plants with Light Water Reactors (Generation 2)
- Safety analysis and methods for safety assessment
- Validation of numerical simulation tools for safety demonstration
- Introduction to probabilistic safety assessment (PSA)
- Nuclear events and accidents
- Safety concepts of reactors of generation 3 and 4

**Literature**

Lecture notes

**Course: Computational Vehicle Dynamics [2162256]****Coordinators:** C. Proppe**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination, no auxiliary means allowed

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

This course serves as an introduction to the computational modelling and simulation of the technical system road/vehicle. A method based perspective is taken, which allows for a unified treatment of various kinds of vehicles. The vehicle model is obtained by dividing the system into functional subsystems and defining interfaces between these subsystems. In the first part of the course, vehicle models will be developed based on models of the suspensions, the road, and the contact forces between road and vehicle. The focus of the second part of the course is on computational methods for linear and non-linear models of vehicle systems. The third part of the course discusses design criteria for stability, safety and ride comfort. The multi body dynamics software Simpack will be used.

**Content**

1. Introduction
2. Models of load bearing systems
3. Contact forces between wheels and roadway
4. Simulation of roadways
5. Vehicle models
6. Methods of calculation
7. Performance indicators

**Literature**

1. K. Popp, W. Schiehlen: Fahrzeugdynamik, B. G. Teubner, Stuttgart, 1993
2. H.-P. Willumeit: Modelle und Modellierungsverfahren in der Fahrzeugdynamik, B. G. Teubner, Stuttgart, 1998
3. H. B. Pacejka: Tyre and Vehicle Dynamics. Butterworth Heinemann, Oxford, 2002
4. K. Knothe, S. Stichel: Schienenfahrzeugdynamik, Springer, Berlin, 2003

**Remarks**

The course takes place every two years (impair years only).

**Course: Computerized Multibody Dynamics [2162216]****Coordinators:** W. Seemann**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral exam

**Conditions**

Knowledge of EM III, EM IV

**Learning Outcomes**

Goal of the course is to demonstrate the students that many tasks which are necessary to derive the equations of motion can be done by computers and corresponding software. This enables the user to focus both on mechanics and on modelling. This includes both kinematics as well as dynamics and different methods to derive the equations of motion. The numerical integration is known and the students realize that the result of the simulation does not only depend on the physical model but also on the type of integration scheme and the corresponding parameters. Application of software without detailed knowledge of the principles which are behind this software is therefore dangerous.

**Content**

Description of the orientation of a rigid body, angular velocity, angular acceleration, derivatives in different reference frames, derivatives of vectors, holonomic and nonholonomic constraints, derivation of the equations of motion using d'Alembert's principle, the principle of virtual power, Lagrange's equations or Kane's equations. Structure of the equations of motion, foundations of numerical integration.

**Media**

Following Programs are used: AUTOLEV, MATLAB, MATHEMATICA/MAPLE

**Literature**

Kane, T.: Dynamics, Theory and Applications, McGrawHill, 1985

AUTOLEV: User Manual

## Course: Computer Integrated Planning of New Products [2122387]

**Coordinators:** R. Kläger

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral examination

Duration:

30 minutes

No tools or reference materials may be used during exam.

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

The students got a basic understanding of relations, procedures and structure elements of standard processes in product planning and are capable of using these as guidelines for planning of new products.

They acquired knowledge of requirements and options in choosing and applying the right methods and tools for an efficient and reasonable assistance for specific use cases.

The students are familiar with elements and methods of computer aided idea and innovation management. They acquired knowledge of simultaneous assistance to the product planning process by using the technologies of rapid prototyping during development phases.

### Content

The increase in creativity and the strength of innovation for the planning and development of new products has become a key factor for the competitiveness of the industry. Shorter innovation cycles, an overwhelming flood of information and an increasing demand for information and communication makes the use of computer absolutely necessary. Against this background this lecture discusses the success factors for new products, and introduces a product innovation process in conjunction with planning of new products based on the concepts of system engineering. In the following the methodological assistance to this process is being discussed by introducing innovation management, idea management, problem solving strategies, creativity and rapid prototyping for instance.

### Literature

Handouts during lecture

## Course: Computational Mechanics I [2161250]

**Coordinators:** T. Böhlke, T. Langhoff

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

### Learning Control / Examinations

oral examination

Prerequisites by attestations during associated tutorials

### Conditions

None.

### Recommendations

Lectures “Mathematical Methods in Strength of Materials” and “Introduction to the Finite Element Method”

This course is geared to MSc students.

### Learning Outcomes

The students can

- analyse and evaluate different methods for solving linear systems of equations
- list and assess basics and assumptions of the linear elasticity
- list methods for solving the boundary value problem of linear elasticity
- apply and evaluate the matrix displacement method
- list and analyse variational principles of linear elasticity
- analyse the different aspects and steps of the finite-element-method
- solve worksheet problems to topics of the lecture by writing own MATLAB code

### Content

- numerical solution of linear systems
- basics of boundary value problems of linear elasticity
- solution methods of boundary value problem of linear elasticity;
- matrix displacement method
- variational principles of linear elasticity
- finite-element-technology for linear static problems

### Literature

Simó, J.C.; Hughes, T.J.R.: Computational Inelasticity. Springer 1998.

Haupt, P.: Continuum Mechanics and Theory of Materials. Springer 2002.

Belytschko, T.; Liu, W.K.; Moran, B.: Nonlinear FE for Continua and Structures. JWS 2000.

W. S. Slaughter: The linearized theory of elasticity. Birkhäuser, 2002.

J. Betten: Finite Elemente für Ingenieure 2, Springer, 2004.

**Course: Computational Mechanics II [2162296]****Coordinators:** T. Böhlke, T. Langhoff**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Summer term | de                   |

**Learning Control / Examinations**

oral examination

**Conditions**

Successful participation in lecture "Computational Mechanics I"

**Recommendations**

This course is geared to MSc students.

**Learning Outcomes**

The students can

- apply and evaluate algorithms for solving a non-linear equation of systems of equations
- compute stresses and strains in the framework of linear elasticity and of infinitesimal plasticity
- apply and assess models of generalized standard materials
- list the basic equations of linear thermo-elasticity
- develop user-subroutines within FORTRAN for use within commercial FE-Codes
- perform a finite-element-analysis with ABAQUS for elastic-plastic materials using or developing user-subroutines

**Content**

- overview quasistatic nonlinear phenomena
- numerics of nonlinear systems
- foundations of nonlinear continuum mechanics
- balance equations of geometrically nonlinear solid mechanics
- finite elasticity
- infinitesimal plasticity
- linear and geometrically nonlinear thermoelasticity

**Literature**

Simó, J.C.; Hughes, T.J.R.: Computational Inelasticity. Springer 1998. Haupt, P.: Continuum Mechanics and Theory of Materials. Springer 2002. Belytschko, T.; Liu, W.K.; Moran, B.: Nonlinear FE for Continua and Structures. JWS 2000.

## Course: Reduction methods for the modeling and the simulation of combustion processes [2166543]

**Coordinators:** V. Bykov, U. Maas

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral

Duration: 30 min.

### Conditions

None

### Recommendations

None

### Learning Outcomes

After completing this course students can:

- 
- explain the fundamental mathematical concepts in model reduction for reacting flows.
- perform an analysis of kinetic models of reacting flows.
- analyse ideal and reduced models used to describe different combustion regimes
- understand and assess the predominant methods for the mathematical analysis of reduced models.

### Content

Fundamentals of the mathematical methods and the analysis of chemical kinetics

Methodology of model reduction and its implementation

Description of different combustion regimes (e.g. auto-ignition, steady flames, flame quenching) with simplified and idealised models

Examples of reduction strategies

### Literature

Course notes

N. Peters, B. Rogg: Reduced kinetic mechanisms for application in combustion systems, Lecture notes in physics, 15, Springer Verlag, 1993

## Course: Renewable Energy – Resources, Technology and Economics [2581012]

**Coordinators:** R. McKenna

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3,5          | 2/0            | Winter term | en                   |

### Learning Control / Examinations

The assessment consists of a written exam according to Section 4(2), 1 of the examination regulation.

### Conditions

None.

### Learning Outcomes

The student:

- 
- understands the motivation and the global context of renewable energy resources.
- gains detailed knowledge about the different renewable resources and technologies as well as their potentials.
- understands the systemic context and interactions resulting from the increased share of renewable power generation.
- understands the important economic aspects of renewable energies, including electricity generation costs, political promotion and marketing of renewable electricity.
- is able to characterize and where required calculate these technologies.

### Content

1. General introduction: Motivation, Global situation
2. Basics of renewable energies: Energy balance of the earth, potential definition
3. Hydro
4. Wind
5. Solar
6. Biomass
7. Geothermal
8. Other renewable energies
9. Promotion of renewable energies
10. Interactions in systemic context
11. Excursion to the “Energieberg” in Mühlburg

### Media

Media will be provided on the e-learning platform ILIAS.

### Literature

#### Elective literature:

- 
- Kaltschmitt, M., 2006, Erneuerbare Energien : Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, aktualisierte, korrigierte und ergänzte Auflage Berlin, Heidelberg : Springer-Verlag Berlin Heidelberg.
- Kaltschmitt, M., Streicher, W., Wiese, A. (eds.), 2007, Renewable Energy: Technology, Economics and Environment, Springer, Heidelberg.
- Quaschnig, V., 2010, Erneuerbare Energien und Klimaschutz : Hintergründe - Techniken - Anlagenplanung – Wirtschaftlichkeit München : Hanser, Ill.2., aktualis. Aufl.
- Harvey, D., 2010, Energy and the New Reality 2: Carbon-Free Energy Supply, Eathscan, London/Washington.
- Boyle, G. (ed.), 2004, Renewable Energy: Power for a Sustainable Future, 2<sup>nd</sup> Edition, Open University Press, Oxford.

**Course: Rheometry and Rheology [22949]****Coordinators:** N. Willenbacher, B. Hochstein**Part of the modules:** Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content**

## Course: Rail Vehicle Technology [2115996]

**Coordinators:** P. Gratzfeld

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

### Learning Control / Examinations

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

### Conditions

none

### Recommendations

none

### Learning Outcomes

The students learn about advantages and disadvantages of different types of traction drives and judge which one fits best for each application.

They understand brakes from a vehicular and an operational point of view. They assess the fitness of different brake systems.

They know about the basics of running dynamics and bogies.

They define suitable vehicle concepts based on requirements for modern rail vehicles.

### Content

Vehicle system technology: structure and main systems of rail vehicles

Drives: Electric and non-electric traction drives

Brakes: Tasks, basics, principles, brake control

Bogies: forces, running gears, axle configuration

Vehicle concepts: trams, metros, regional trains, double deck coaches, locomotives

Examples of existing rail vehicles were discussed.

### Media

All slides are available for download (Ilias-platform).

### Literature

A bibliography is available for download (Ilias-platform).

### Remarks

None.

**Course: Fatigue of Metallic Materials [2173585]****Coordinators:** K. Lang**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

none

**Conditions**

none, basic knowledge in Material Science will be helpful

**Learning Outcomes**

The students are able to recognise the deformation and the failure behaviour of metallic materials under cyclic loading and to assign it to the basic microstructural processes. They know the sequence and the development of fatigue damages and can evaluate the initiation and the growth of fatigue cracks.

The students can assess the cyclic strength behaviour of metallic materials and components both qualitatively and quantitatively and know the procedures for the assessment of single-stage, multistage and stochastic cyclical loadings. Furthermore, they can take into account the influence of residual stresses.

**Content**

Introduction: some interesting cases of damage

Cyclic Stress Strain Behaviour

Crack Initiation

Crack Propagation

Lifetime Behaviour under Cyclic Loading

Fatigue of Notched Components

Influence of Residual Stresses

Structural Durability

**Literature**

Lecture notes that include a list of current literature will be distributed.

## Course: Schwingungstechnisches Praktikum [2161241]

**Coordinators:** H. Hetzler, A. Fidlin

**Part of the modules:** Specialized Practical Training (p. 56)[MSc-Modul 07, FP]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 3              | Summer term | de                   |

### Learning Control / Examinations

Colloquium to each session.

### Conditions

None.

### Recommendations

Vibration theory, mathematical methods of vibration theory, dynamic stability, nonlinear vibrations

### Learning Outcomes

- \* Introduction to common measurement principles for mechanical vibrations
- \* selected vibrational problems are demonstrated from a theoretical and experimental aspect
- \* Measurement, evaluation and comparison with analytical calculations.

### Content

- \* Frequency response of a force-excited oscillator (1DoF)
- \* stochastically excited oscillator (1DoF)
- \* digital processing of measurement data
- \* forces vibrations of a Duffing oscillator
- \* isolation of acoustical waves by means of additional masses
- \* critical speeds of a rotor in elastic bearings
- \* stability of a parametrically excited oscillator
- \* experimental modal analysis
- \* friction induced vibrations

### Literature

comprehensive instructions will be handed out

**Course: Safety Engineering [2117061]****Coordinators:** H. Kany**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", version of 29.06.2011)

examination aids: none

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Students are able to:

- Name and describe relevant safety concepts of safety engineering,
- Discuss basics of health at work and labour protection in Germany,
- Evaluate the basics for the safe methods of design of machinery with the national and european safety regulations and
- Realize these objectives by using examples in the field of storage and material handling systems.

**Content**

The course provides basic knowledge of safety engineering. In particular the basics of health at the working place, job safety in Germany, national and European safety rules and the basics of safe machine design are covered. The implementation of these aspects will be illustrated by examples of material handling and storage technology. This course focuses on: basics of safety at work, safety regulations, basic safety principles of machine design, protection devices, system security with risk analysis, electronics in safety engineering, safety engineering for storage and material handling technique, electrical dangers and ergonomics. So, mainly, the technical measures of risk reduction in specific technical circumstances are covered.

**Media**

presentations

**Literature**

Defren/Wickert: Sicherheit für den Maschinen- und Anlagenbau, Druckerei und Verlag: H. von Ameln, Ratingen, ISBN: 3-926069-06-6

**Remarks**

none

**Course: [23109]****Coordinators:** F. Puente, F. Puente León**Part of the modules:** Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4.5          | 2/1            | Winter term | de                   |

**Learning Control / Examinations**

The assessment consists of a written exam (approx. 120 minutes) according to sec. 4 subsec. 2 no. 1 study and examination regulations.

The grade of the course corresponds to the grade of the written exam.

**Conditions**

Knowledge of higher mathematics and probability theory (1305) is required.

**Learning Outcomes****Content****Media**

Slides

work sheets

**Literature**

Prof. Dr.-Ing. Kiencke: Signale und Systeme; Oldenbourg Verlag, 2008

**Elective literature:**

Will be announced in the lecture.

## Course: Simulation of Coupled Systems [2114095]

**Coordinators:** M. Geimer

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 4              | Summer term | de                   |

### Learning Control / Examinations

The assessment consists of an oral exam (20 min) taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

### Conditions

It is recommended to have:

- Knowledge of ProE (ideally in current version)
- Basic knowledge of Matlab/Simulink
- Basic knowledge of dynamics of machines
- Basic knowledge of hydraulics

### Learning Outcomes

After completion of the course, students are able to:

- building a coupled simulation
- parameterize models
- Perform simulations
- do Troubleshooting
- check results for plausibility

### Content

- Knowledge of the basics of multi-body and hydraulic simulation programs
- Possibilities of coupled simulations
- Development of a simulation model by using the example of a wheel loader
- Documentation of the result in a short report

### Literature

#### Elective literature:

- miscellaneous guides according the software-tools pdf-shaped
- information to the wheel-type loader

## Course: Simulation of production systems and processes [2149605]

**Coordinators:** K. Furmans, V. Schulze, P. Stock

**Part of the modules:** Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 4              | Winter term | de                   |

### Learning Control / Examinations

**Supplementary Subject, Elective Subject Economics/Law, Compulsory Elective Subject:** The assessment is carried out as a written exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

**Elective Subject:** The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None.

### Recommendations

Regular attendance in the exercises.

### Learning Outcomes

The students . . .

- can explain the procedure of a simulation study and the respective steps.
- are able to explain the different modeling approaches that are available to describe production systems in matters of production technology, systems of work and material flow, to analyze and evaluate the results.
- are able to define the different modeling approaches for the description of machining processes and their advantages and disadvantages.
- are able to specify methods for simulation of plants and factories and classify them according to their capabilities.
- are able to define basics in statistics.
- are able to both calculate performance indicators of material flow systems and evaluate real systems according to these performance indicators.
- are able to use the basic tools of a discrete-event simulation software and can evaluate simulation results.
- are able to describe how real systems can be modeled as well as how models can be used and their results can be evaluated.
- are able to perform a personnel-oriented simulation study and can evaluate its results concerning different key figures.
- are able to apply common techniques for verification and simulation and can evaluate the validity of a simulation study with these techniques.

### Content

The aim of the lecture is to present the different aspects and possibilities of application of simulation technologies in the field of production systems and processes. Various simulation methods in the fields of production and manufacturing technology, work systems and the material flow for the production systems will be presented.

The following topics will be covered:

- Statistical basics (probability distribution and random numbers and their applications in the Monte Carlo simulation)

- Simulation of factories, machinery and processes (analysis of single manufacturing processes, machine tools and a digital plant)
- Simulation of work systems (personnel and oriented simulation of the digital plant)
- Design and validation of the simulations study (the procedure of a simulations study with the preparation work, the selection of the tools, the validation and the analysis/evaluation)

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

**Course: Scaling in fluid dynamics [2154044]****Coordinators:** L. Bühler**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 minutes

no auxiliary means

**Conditions**

none

**Learning Outcomes**

The student can extract non-dimensional number from the characteristic properties of flows. From the insights on scaling laws, the students are qualified to identify the influencing quantities from generic experiments and transfer these to real applications. The students can simplify the governing equations of fluid mechanic appropriately and can interpret the achieved results as a basis for efficient solution strategies.

**Content**

- Introduction
- Similarity rules (examples)
- Dimensional analysis (Pi-theorem)
- Scaling in differential equations
- Scaling in boundary layers
- Self-similar solutions
- Scaling in turbulent shear layers
- Rotating flows
- Magnetohydrodynamic flows

**Literature**

G. I. Barenblatt, 1979, Similarity, Self-Similarity, and Intermediate Asymptotics, Plenum Publishing Corporation (Consultants Bureau)

J. Zierep, 1982, Ähnlichkeitsgesetze und Modellregeln der Strömungsmechanik, Braun

G. I. Barenblatt, 1994, Scaling Phenomena in Fluid Mechanics, Cambridge University Press

## Course: Theory of Stability [2163113]

**Coordinators:** A. Fidlin

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

### Learning Control / Examinations

Oral examination

Duration: 30 min (optional subject)

20 min (major subject)

Means are not allowed

### Conditions

None.

### Recommendations

Vibration theory, mathematical methods of vibration theory

### Learning Outcomes

- to learn the most important methods of the stability analysis
- to apply the stability analysis for equilibria
- to apply the stability analysis for periodic solution
- to apply the stability analysis for systems with feedback control

### Content

- Basic concepts of stability
- Lyapunov's functions
- Direct Lyapunov's methods
- Stability of equilibria positions
- Attraction area of a stable solution
- Stability according to the first order approximation
- Systems with parametric excitation
- Stability criteria in the control theory

### Literature

- Pannovko Y.G., Gubanov I.I. Stability and Oscillations of Elastic Systems, Paradoxes, Fallacies and New Concepts. Consultants Bureau, 1965.
- Hagedorn P. Nichtlineare Schwingungen. Akademische Verlagsgesellschaft, 1978.
- Thomsen J.J. Vibration and Stability, Order and Chaos. McGraw-Hill, 1997.

**Course: Control Technology [2150683]****Coordinators:** C. Gönzheimer**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment is carried out as an oral exam. The examination is offered every semester twice. Reexaminations are offered at every ordinary examination date.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The students . . .

- are able to name the electrical controls which occur in the industrial environment and explain their function.
- can explain fundamental methods of signal processing. This involves in particular several coding methods, error protection methods and analog to digital conversion.
- are able to choose and to dimension control components, including sensors and actors, for an industrial application, particularly in the field of plant engineering and machine tools. Thereby, they can consider both, technical and economical issues.
- can describe the approach for projecting and writing software programs for a programmable logic control named Simatic S7 from Siemens. Thereby they can name several programming languages of the IEC 1131.

**Content**

The lecture control technology gives an integral overview of available control components within the field of industrial production systems. The first part of the lecture deals with the fundamentals of signal processing and with control peripherals in the form of sensors and actors which are used in production systems for the detection and manipulation of process states. The second part handles with the function of electric control systems in the production environment. The main focus in this chapter is laid on programmable logic controls, computerized numerical controls and robot controls. Finally the course ends with the topic of cross-linking and decentralization with the help of bus systems.

The lecture is very practice-oriented and illustrated with numerous examples from different branches.

The following topics will be covered

- Signal processing
- Control peripherals
- Programmable logic controls
- Numerical controls
- Controls for industrial robots
- Process control systems
- Field bus
- Trends in the area of control technology

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

## Course: Strategic Product Planing [2146193]

**Coordinators:** A. Siebe

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral exam

duration: 20 minutes

### Conditions

none

### Learning Outcomes

After listening to this lecture the students is able to ...

- describe the importance and goals of future management in product planning.
- to evaluate the different approaches of strategic product planning under consideration of the particular application.
- describe the approaches of a strategic szenario-based product planning.
- illustrate the strategic szenario-based product planning based on examples.

### Content

Introduction into future management, Development of scenarios, scenariobased strategy development, trendmanagement, strategic early detection, innovation- and technologymanagement, scenarios in product development, from profiles of requirements to new products, examples out of industrial praxis.

**Course: Flows in rotating systems [2154407]****Coordinators:** R. Bohning**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes (optional subject), 20 minutes (major subject)

No tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

The students can describe the fundamental phenomena involved as well as the mathematical and physical aspects of rotating fluid flows, which occur in a wide variety of technical contexts and in geophysics, particularly in the atmosphere and in the oceans. They are qualified to transfer the obtained knowledge for characteristic flow problems of this field to practical examples.

**Content**

- Introduction
- Governing equations in a rotating System
- Exact solutions (circular flows)
- Dynamic similarity (Rossby Number Ekman Number)
- Hyperbolicity (Inertia waves, Rossby waves)
- Taylor Proudman theorem
- Ekman-layer
- Instabilities in rotating systems

**Literature**

Greenspan, H. P.: The Theory of Rotating Fluids

Lugt, H. J.: Wirbelströmungen in Natur und Technik, Braun Verlag, Karlsruhe, 1979

Lugt, H. J.: Vortex Flow in Rotating Fluids (with Mathematical Supplement), Wiley Interscience

Pedlovsky, J.: Geophysical Fluid Dynamic

**Course: Flows with chemical reactions [2153406]****Coordinators:** A. Class**Part of the modules:** Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 min  
as WF NIE  
written homework

Lecture

**Conditions**

Mathematics

**Learning Outcomes**

The students can describe flow scenarios, where a chemical reaction is confined to a thin layer. They can choose simplifying approaches for the underlying chemistry and discuss the problems with focus on the fluid mechanic aspects. The students are able to solve simple problems analytically. Furthermore, they are qualified to discuss simplifications as relevant for an efficient numerical solution of complex problems.

**Content**

In the lecture we mainly consider problems, where chemical reaction is confined to a thin layer. The problems are solved analytically or they are at least simplified allowing for efficient numerical solution procedures. We apply simplified chemistry and focus on the fluid mechanic aspects of the problems.

**Media**

Black board

**Literature**

Lecture

Buckmaster, J.D.; Ludford, G.S.S.: Lectures on Mathematical Combustion, SIAM 1983

## Course: Flows and Heat Transfer in Energy Technology [2189910]

**Coordinators:** X. Cheng

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral examination; duration: 20min

### Conditions

None.

### Learning Outcomes

This lecture is dedicated to students of mechanical engineering and other engineering Bachelor or Master degree courses. Goal of the lecture is the understanding of major processes in fluid dynamics and heat transfer in energy engineering. The corresponding phenomena and the methods to analyse are described and explained. In addition the lecture will be supplemented by convenient examples.

### Content

1. collection of sample applications
2. heat transfer and its application
3. convective fluid dynamics and heat transfer
4. thermal radiation and its application
5. special cases

### Literature

- Bahr, H.D., Stephan, K., Wärme- und Stoffübertragung, 3. Auflage Springer Verlag, 1998
- Mueller, U., Zweiphasenströmung, Vorlesungsmanuskript, Februar 2000, TH Karlsruhe
- Mueller, U., Freie Konvektion und Wärmeübertragung, Vorlesungsmanuskript, WS1993/1994, TH Karlsruhe
- W. Oldekop, „Einführung in die Kernreaktor und Kernkraftwerktechnik,“ Verlag Karl Thiemig, München, 1975
- Cacuci, D.G., Badea, A.F., Energiesysteme I, Vorlesungsmanuskript, 2006, TH Karlsruhe
- Jones, O.C., Nuclear Reactor Safety Heat Transfer, Hemisphere Verlag, 1981
- Herwig, H., Moschallski, A., Wärmeübertragung, 2. Auflage, Vieweg + Teubner, 2009

**Course: Structural and phase analysis [2125763]****Coordinators:** S. Wagner**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

20 min

auxiliary means: none

**Conditions**

None.

**Learning Outcomes**

The students know the fundamentals of crystallography, the generation and detection of x-rays as well as their interaction with the microstructure of crystalline materials. They have detailed knowledge about the different methods of x-ray diffraction measurements and are able to analyze x-ray spectra using modern methods of x-ray analysis both qualitatively and quantitatively.

**Content**

The course gives an overview to generation and detection of x-rays as well as their interaction with matter. It provides an introduction to crystallography and describes modern measurement and analysis methods of x-ray diffraction.

It is arranged in the following units:

- 
- Generation and properties of X-Ray's Crystallography
- Fundamentals and application of different measuring methods
- Qualitative and quantitative phase analysis
- Texture analysis (pole figures)
- Residual stress measurements

**Literature**

- 1.
2. B.D. Cullity and S.R. Stock: Elements of X-ray diffraction. Prentice Hall New Jersey, 2001.

**Course: Structural Ceramics [2126775]****Coordinators:** M. Hoffmann**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (20 min) taking place at the agreed date.

Auxiliary means: none

The re-examination is offered upon agreement.

**Conditions**

none

**Recommendations**

Basics of the course "Introduction to Ceramics" should be known.

**Learning Outcomes**

The students know the most relevant structural ceramics (silicon carbide, silicon nitride, alumina, boron nitride, zirconia, fibre-reinforced ceramics) and their applications. They are familiar with the microstructural features, fabrication methods, and mechanical properties.

**Content**

The lecture gives an overview on structure and properties of the technical relevant structural ceramics silicon nitride, silicon carbide, alumina, zirconia, boron nitride and fibre-reinforced ceramics. All types of structural ceramics will be discussed in detail in terms of preparation methods of the raw materials, shaping techniques, densification, microstructural development, mechanical properties and application fields.

**Media**

Slides for the lecture:

available under <http://www.iam.kit.edu/km>

**Literature**

W.D. Kingery, H.K. Bowen, D.R. Uhlmann, "Introduction to Ceramics", John Wiley & Sons, New York, (1976)

E. Dörre, H. Hübner, "Alumina", Springer Verlag Berlin, (1984)

M. Barsoum, "Fundamentals of Ceramics", McGraw-Hill Series in Material Science and Engineering (2003)

**Remarks**

The course will not take place every year.

## Course: Superconducting Materials for Energy Applications [23682]

**Coordinators:** M. Noe, F. Grilli

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | en                   |

### Learning Control / Examinations

The examination results from the chosen module, otherwise:  
Oral exam, about 25 min.

### Conditions

None.

### Learning Outcomes

After attending this course, the students will have

- Received an introduction to superconductivity, with an overview of its main features and of the theories developed to explain it;
- Learned about superconducting materials and their properties, especially those currently employed in energy applications (niobium-based superconductors, cuprates, MgB<sub>2</sub>) and promising recently discovered ones (pnictides);
- Familiarized with the wide range of superconducting energy applications (magnets, cables, fault current limiters, motors, transformers, etc.), and learned about the advantages they offer with respect to their conventional counterparts.

### Content

- Introduction of the course
- Basics of superconductivity
- Materials I (low- $T_c$  superconductors)
- Materials II (high- $T_c$  superconductors)
- Stability
- AC losses
- Simulation and modeling
- Cables
- Fault current limiters
- Magnets, motors, transformers
- Smart-grids
- Lab tour

### Media

Blackboard, PowerPoint slides, script written by the teacher (100+ pages)

### Literature

Various. It will be provided on a lecture-by-lecture basis.

### Remarks

Current information can be found on the IMS ([www.ims.kit.edu](http://www.ims.kit.edu)) webpage. At the end of the course an excursion is planned to KIT Campus North (ITEP).

**Course: Superhard Thin Film Materials [2177618]****Coordinators:** S. Ulrich**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination (30 min)

no tools or reference materials

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

Superhard materials are solids with a hardness higher than 4000 HV 0,05. The main topics of this lecture are modelling, deposition, characterization and application of superhard thin film materials.

**Content**

Introduction

Basics

Plasma diagnostics

Particle flux analysis

Sputtering and ion implantation

Computer simulations

Properties of materials, thin film deposition technology, thin film analysis and modelling of superhard materials

Amorphous hydrogenated carbon

Diamond like carbon

Diamond

Cubic Boronnitride

Materials of the system metall-boron-carbon-nitrogen-silicon

**Literature**

G. Kienel (Ed.): Vakuumbeschichtung 1 - 5, VDI Verlag, Düsseldorf, 1994

Copies with figures and tables will be distributed

**Course: Supply chain management [2117062]****Coordinators:** K. Alicke**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

No tools or reference materials may be used during the exam.

**Conditions**

limited number: application necessary

**Recommendations**

none

**Learning Outcomes**

Students are able to:

- Discuss the requirements on modern supply chains,
- Use the basic concepts of demand forecast, stock optimization and supply in practical exercises,
- Analyse the typical questions of dimensioning a supply chain and evaluate a supply chain with the results.

**Content**

- Bullwhip-Effect, Demand Planning & Forecasting
- Conventional planning processes (MRP + MRP II)
- Stock keeping strategy
- Data acquisition and analysis
- Design for logistics (Postponement, Mass Customization, etc.)
- Logistic partnerships (VMI, etc.)
- Distribution structures (central vs. distributed, Hub&Spoke)
- SCM-metrics (performance measurement) e-business
- Special sectors as well as guest lectures

**Media**

presentations

**Literature**

Alicke, K.: Planung und Betrieb von Logistiknetzwerken

Simchi-Levi, D., Kaminsky, P.: Designing and Managing the Supply Chain

Goldratt, E., Cox, J.: The Goal

**Remarks**

this course is a block course

## Course: Sustainable Product Engineering [2146192]

**Coordinators:** K. Ziegahn

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

### Learning Control / Examinations

The type of examination (written or oral) will be announced at the beginning of the lecture.

written examination: 60 min duration

oral examination: 20 min duration

### Conditions

none

### Learning Outcomes

The goal of the lecture is to convey the main elements of sustainable product development in the economic, social and ecological context.

The students are able to ...

- identify und describe the sustainability objectives and their role in product development, the interaction between technical products and their environment, the holistic approach and the equality of economic, social and environmental aspects and environmental aspects.
- discuss the skills for life-cycle product design using the example of complex automotive components such as airbag systems and other current products.
- understand the product environmental stresses with relevancy to praxis at the example of technology-intensive components, robustness and durability of products as the basis for a sustainable product development, development of skills for the application of environmental simulation during the process of development of technical products.
- develop skills such as team skills / project / self / presentation based on realistic projects.

### Content

understanding of sustainability objectives and their role in product development, the interaction between technical products and their environment, the holistic approach and the equality of economic, social and environmental aspects and environmental aspects

skills for life-cycle product design using the example of complex automotive components such as airbag systems and other current products

understanding of product environmental stresses with relevancy to praxis at the example of technology-intensive components, robustness and durability of products as the basis for a sustainable product development, development of skills for the application of environmental simulation during the process of development of technical products

delivery of key skills such as team skills / project / self / presentation based on realistic projects

## Course: Systematic Materials Selection [2174576]

**Coordinators:** J. Hoffmeister

**Part of the modules:** Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

### Learning Control / Examinations

The assessment is carried out as a written exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

Basic knowledge in materials science and engineering, mechanics and mechanical design

### Learning Outcomes

The students are able to select the best material for a given application. They are proficient in selecting materials on base of performance indices and materials selection charts. They can identify conflicting objectives and find sound compromises. They are aware of the potential and the limits of hybrid material concepts (composites, bimaternal, foams) and can determine whether following such a concept yields a useful benefit.

### Content

Important aspects and criteria of materials selection are examined and guidelines for a systematic approach to materials selection are developed. The following topics are covered:

- Information and introduction
- Necessary basics of materials
- Selected methods / approaches of the material selection
- Examples for material indices and materials property charts
- Trade-off and shape factors
- Sandwich materials and composite materials
- High temperature alloys
- Regard of process influences
- Material selection for production lines
- Incorrect material selection and the resulting consequences
- Abstract and possibility to ask questions

### Literature

Lecture notes; Problem sheets; Textbook: M.F. Ashby, A. Wanner (Hrsg.), C. Fleck (Hrsg.); Materials Selection in Mechanical Design: Das Original mit Übersetzungshilfen Easy-Reading-Ausgabe, 3. Aufl., Spektrum Akademischer Verlag, 2006  
ISBN: 3-8274-1762-7

## Course: Systems and Software Engineering [23605]

**Coordinators:** K. Müller-Glaser

**Part of the modules:** Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term |                      |

### Learning Control / Examinations

Written exam.

### Conditions

None.

### Recommendations

Knowledge of the fundamentals of digital systems design and information technology.

### Learning Outcomes

After attendance of the course students are able to:

- solve complex tasks in a structured and targeted way by applying methods, techniques and tools presented in the lecture.
- understand the concepts of System, systems engineering and software engineering.
- describe mathematical models of embedded systems and life cycle models.
- define specifications and develop project requirement documents and functional specifications applying description techniques and specification languages and formalisms.
- understand important topics of hardware design such as state charts, realization alternatives for electronic computation systems, aspects of concurrency and parallelization, pipelining, scheduling, real time systems and appropriate operating systems.
- describe mathematical models for reliability and operability of complex electronic systems as well as risk assessment and simplified representations .
- describe the fundamentals of various languages and representations in software design.
- implement different testing and maintenance approaches.
- apply these fundamentals to specific and practical problems.

### Content

The lecture Systems and Software Engineering is directed to all students, who themselves want to be challenged with the design of complex electronic systems with hardware and software components. It will introduce to students the tools, which allow for a structured solution to complex Problems. The lecture specially dwells on development processes, hardware design, software design, reliability as well as various aspects of modeling.

The lecture initially differentiates the terms system, systems engineering and software engineering. Life cycle models and methods for mathematical modeling of embedded electronic systems as well as lifecycle models (Waterfall model, V-Model and Hunger Model) are introduced. The focuses of the lecture are the early phases of system development, starting with definitions of requirements as well as the creation of project requirement documents and functional specifications. Aspects of requirements documentation methods and description techniques as well as specification languages and formalisms are brought near.

Concrete topics in the area of hardware design are state charts, realization alternatives for electronic computation systems, aspects of concurrency and parallelization, pipelining, scheduling, real time systems and the appropriate operating systems.

The domain reliability thematizes security and operability of complex electronic systems covering their complete lifetime. Mathematical modeling methods as well as risk analysis and simplified presentations like block diagrams are discussed.

Besides the various diagrams and modeling perspectives of UML (Use Case diagram, class diagram, object diagram, communication diagram, sequence diagram, package diagram, etc.) the area of software design covers dataflow diagram, Petri nets as well as various languages like the ENBF.

Testing and maintenance form another essential aspect of the system development. Approaches and procedures like black box testing and white box testing are presented and form a basic understanding for the importance of testing, verification and validation as well as quality assurance all over the development period.

#### Exercise

Exercises concerning the lecture as well as their appropriate solutions are handed out and discussed in the lecture hall exercise session. Transferring the lecture's theoretical content to examples with practical orientation clarify the usage and necessity of techniques for modeling and representation techniques.

#### Literature

Course book online [estudium.fsz.kit.edu](http://estudium.fsz.kit.edu).

## Course: Theoretical Description of Mechatronic Systems [2161117]

**Coordinators:** W. Seemann

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral

30 minutes (optional subject), 20 minutes (major subject)

### Conditions

None.

### Learning Outcomes

Aim of the course is to provide principles and tools to derive the mathematical models of mechatronic systems. The students are able to generate physical models of mechatronic systems. They know the description by across and through variables. With the help of energy principles variational methods can be applied to electromechanic systems. The basics of applied mechanics and electric systems are known. The students are able to complete the mechatronic system by a corresponding control.

### Content

Basics for the theoretical modeling by synthetic and analytical methods. Classification of elements of the system, fundamental equations, constitutive equations. Kinetic potential, virtual work, systems with distributed parameters, Hamilton's principle, all for mechatronic systems. Background for experimental modeling of mechatronic systems. Foundations of solid and fluid mechanics. Basics of electronics (Maxwell's equations, electric and magnetic field, modelling of electronic circuits, analogue parts). Sensors and actuators as well as converter principles. Summary of control of mechatronic systems, especially digital control.

### Literature

Script of the course.

Isermann, R.: Mechatronische Systeme, Springer, 1999.

Heimann, B., Gerth, W., Popp, K.: Mechatronik. Hanser, 1998

Riemer, M., Wauer, J., Wedig, W.: Mathematische Methoden der Technischen Mechanik. Springer, 1993

**Course: Technical Acoustics [2158107]****Coordinators:** M. Gabi**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes

No tools or reference materials may be used during the exam.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Students get to know the basics of technical acoustics in general. Application of the knowledge in different fields of engineering.

Students learn physical basics of acoustics and human perception. Physical-empirical laws for determination of sound and noise levels of various emission and immission situations will be worked out or derived. Furtheron general sound measurement methods of machinery will be taught.

Students are able to understand mechanisms of sound origin, propagation and reduction, as well as measuring technics

**Content**

Basics of acoustics

Perception and weighting of noise (human hearing)

Description of acoustic parameters, level notation

Noise propagation

Acoustical measurement techniques

**Literature**

1. Lecture notes (downloadable from institute's homepage).
2. Heckl, M.; Müller, H. A.: Taschenbuch der Technischen Akustik, Springer-Verlag.
3. Veit, Ivar: Technische Akustik. Vogel-Verlag (Kamprath-Reihe), Würzburg.
4. Henn, H. et al.: Ingenieurakustik. Vieweg-Verlag.

**Course: Computer Engineering [2106002]****Coordinators:** G. Bretthauer**Part of the modules:** Elective Subject Natural Science/Computer Science/Electrical Engineering (p. 60)[MSc-Modul 11, WF NIE], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Written examination

Duration: 2 hours (compulsory subject)

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students possess essential knowledge about information processing in digital computers. Based on information representation and calculations of complexity, students are capable to design algorithms efficiently. The students are able to apply the knowledge about efficient algorithm design to important numerical computation methods in mechanical engineering. Students understand the importance of software quality in mechanical engineering and know basic concepts and important measures of quality assurance.

**Content**

Introduction: definitions, basic concepts, introductory examples

Information coding on finite automata: numbers, characters, commands, examples

Algorithm design: definitions, complexity of algorithms, complexity classes P and NP, examples

Sorting algorithms: relevance, algorithms, simplifications, examples

Software quality assurance: terms and measures, errors, phases of quality assurance, constructive measures, analytical measures, certification

Lectures are complemented by an exercise course.

**Literature**

Vorlesungsskript (Internet)

Becker, B., Molitor, P.: Technische Informatik : eine einführende Darstellung. München, Wien : Oldenbourg, 2008.

Hoffmann, D. W.: Grundlagen der Technischen Informatik. München: Hanser, 2007.

Balzert, H.: Lehrbuch Grundlagen der Informatik : Konzepte und Notationen in UML, Java und C++, Algorithmen und Software-Technik, Anwendungen. Heidelberg, Berlin : Spektrum, Akad. Verl., 1999.

Trauboth, H.: Software-Qualitätssicherung : konstruktive und analytische Maßnahmen. München, Wien : Oldenbourg, 1993.

## Course: Integrated Information Systems for engineers [2121001]

**Coordinators:** J. Ovtcharova

**Part of the modules:** Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

### Learning Control / Examinations

Depending on choice according to actual version of study regulations

### Conditions

None

### Recommendations

None

### Learning Outcomes

Students can:

- illustrate the structure and operating mode of information systems
- explain different goals of specific IT systems in product development (CAD, CAP, CAM, PPS, ERP, PDM) and assign product development processes
- describe the fundamentals of knowledge management and its application in engineering and deploy ontology as knowledge representation
- describe different types of process modelling and their application and illustrate and execute simple work flows and processes with selected tools

### Content

- Information systems, information management
- CAD, CAP and CAM systems
- PPS, ERP and PDM systems
- Knowledge management and ontology
- Process modeling

### Literature

Lecture slides

**Course: Vibration Theory [2161212]****Coordinators:** A. Fidlin**Part of the modules:** Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject PT (p. 44)[MSc-Modul PT, WPF PT], Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Winter term | de                   |

**Learning Control / Examinations**

Written exam

If course is chosen as optional subject or part of major subject:

Oral exam, 30 minutes (optional subject), 20 minutes (major subject), no means

**Conditions**

None.

**Recommendations**

Examen in Engineering Mechanics 3 + 4

**Learning Outcomes**

The course gives an introduction into the vibration theory of linear systems. First, general vibration in form of harmonic signals is considered. One degree of freedom systems are treated in detail for free and forced vibration, especially for harmonic, periodic and arbitrary excitation. This is the foundation for systems with many degrees of freedom as these may be transformed with the help of modal coordinates. For multiple dof systems the eigenvalue problem is solved. Then forced vibration is treated. Finally, wave propagation problems and eigenvalue problems for systems with distributed parameters are discussed. As an application an introduction into rotor dynamics is given.

Goal of the course is to see the similarities for systems with one dof and with multiple dof. Besides typical phenomena like resonance a systematic mathematical approach to vibration problems and an interpretation of the mathematical results should be obtained.

**Content**

Concept of vibration, superposition of vibration with equal and with different frequencies, complex frequency response.

Vibration of systems with one dof: Free undamped and damped vibration, forced vibration for harmonic, periodic and arbitrary excitation. Excitation of undamped vibration in resonance.

Systems with many degrees of freedom: Eigenvalue problem for undamped vibration, orthogonality of eigenvectors, modal decoupling, approximation methods, eigenvalue problem for damped vibration. Forced vibration for harmonic excitation, modal decomposition for arbitrary forced vibration, vibration absorber.

Vibration of systems with distributed parameters: Partial differential equations as equations of motion, wave propagation, d'Alembert's solution, Ansatz for separation of time and space, eigenvalue problem, infinite number of eigenvalues and eigenfunctions.

Introduction to rotor dynamics: Laval rotor in rigid and elastic bearings, inner damping, Laval rotor in anisotropic bearings, synchronous and asynchronous whirl, rotors with asymmetric shaft.

**Literature**

Klotter: Technische Schwingungslehre, Bd. 1 Teil A, Heidelberg, 1978

Hagedorn, Otterbein: Technische Schwingungslehre, Bd 1 and Bd 2, Berlin, 1987

Wittenburg: Schwingungslehre, Springer-Verlag, Berlin, 1995

## Course: Technical Design in Product Development [2146179]

**Coordinators:** M. Schmid

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

For the reason of high student number the exam is a written exam.  
Only dictionary is allowed.

### Conditions

Authorisation by the Examination Office.

### Recommendations

None

### Learning Outcomes

After listening the module „technical design“ the students should have knowledge about the basics of technical oriented design as an integral part of the methodical product development

The students have knowledge about ...

- the interface between engineer and designer.
- all relevant human-product requirements as f. exp. demographic/ geographic and psychographic features, relevant perceptions, typical content recognition as well as ergonomic bases.
- the approaches concerning the design of a product, product program or product system with focus on structure, form-, color- and graphic design within the phases of the design process.
- the design of functions and supporting structures as well as the important interface between human and machine.
- relevant parameters of a good corporate design.

### Content

Introduction

Relevant parameters on product value in Technical Design

Design in Methodical Development and Engineering and for a differentiated validation of products

Design in the concept stage of Product Development

Design in the draft and elaboration stage of Product Development

### Literature

Hexact (R) Lehr- und Lernportal

**Course: Technology of steel components [2174579]****Coordinators:** V. Schulze**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

duration 20 minutes

No tools or reference materials may be used during the exam

**Conditions**

Materials Science and Engineering I &amp; II

**Learning Outcomes**

The students have the background to evaluate the influence of manufacture processes on the compound state of metallic compounds. The students can assess the influence and the stability of compound state under mechanical load. The students are capable to describe the individual aspects of interaction of the compound state of steel components due to forming, heat treatment, mechanical surface treatment and joining processes.

**Content**

Meaning, Development and characterization of component states  
 Description of the influence of component state on mechanical properties  
 Stability of component states  
 Steel manufacturing  
 Component states due to forming  
 Component states due to heat treatments  
 Component states due to surface hardening  
 Component states due to machining  
 Component states due to mechanical surface treatments  
 Component states due to joining  
 Summarizing evaluation

**Literature**

Script will be distributed within the lecture

VDEh: Werkstoffkunde Stahl, Bd. 1: Grundlagen, Springer-Verlag, 1984

H.-J. Eckstein: Technologie der Wärmebehandlung von Stahl, Deutscher Verlag Grundstoffindustrie, 1977

H.K.D.H. Badeshia, R.W.K. Honeycombe, Steels - Microstructure and Properties, CIMA Publishing, 3. Auflage, 2006

V. Schulze: Modern Mechanical Surface Treatments, Wiley, Weinheim, 2005

**Course: Ten lectures on turbulence [2189904]****Coordinators:** I. Otic**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

**Learning Control / Examinations**

oral examination; duration: 20 minutes

**Conditions**

None.

**Recommendations**

- Fundamentals of fluid dynamics

**Learning Outcomes**

After completing the course students should be able to establish a connection between theory and numerical modeling of turbulent flows.

**Content**

This course is specified for Master students of Mechanical, Power and Nuclear Engineering. The problem of turbulence is of key importance in many fields of science and engineering. It is an area which is vigorously researched across a diverse range of disciplines. This course is aimed of giving the fundamentals of turbulence theory and modelling. Starting from the basic physical phenomena and governing equations the quantitative and statistical description of turbulence is introduced. An overview on computational methods for turbulent flows and turbulence modelling is given.

**Course: Materials under high thermal or neutron loads [2194650]****Coordinators:** A. Möslang, M. Rieth**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral Examination (20 min)

**Conditions**

Materials science I

**Recommendations**

none

**Learning Outcomes**

Advanced structural and functional materials for thermally or neutronically highly loaded systems. The students learn property profiles, applications and the interaction between atomic structure, microstructure and macroscopic materials behaviour.

**Content**

- Introduction and basics
- Metallic and ceramic solid state structure
- Transport of matter and conversion in solid state
- Material properties at high heat loads
- Interaction between energetic particles and condensed matter, irradiation damage
- Nanoscaled modelling of damage relevant properties
- State-of-the-art analytical methods with particles
- Highly heat resistant Steels
- Nanoscaled, oxide dispersion strengthened alloys
- Super alloys
- Refractory metals and laminates
- Fibre reinforced structural ceramics
- Light high strength Beryllium alloys
- Oxides and functional materials
- Joining technologies
- Strategies of materials development
- Applications in Fusion, fission, large scale accelerators and concentrated solar power

**Literature**

Presentation with figures and tables, Exercise sheets

**Course: Computational methods for the heat protection of a full vehicle [2157445]****Coordinators:** H. Reister**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination, 30 minutes, no aids

**Conditions**

basics in fluid mechanics and thermodynamics recommended

**Recommendations**

none

**Learning Outcomes**

The students have basic equations to understand thermal situation in vehicles.

They can evaluate thermal situation in vehicles.

The students can utilize methods.

**Content**

In the lecture computational methods for the heat protection of the full vehicle are presented. For this the basic conservation equations are introduced and the applied computational programs are discussed in detail. The aspects concerning fluid mechanics are treated extensively. For this the underhood flow as well as the flow around the vehicle, at the underbody and at the rear of the car are considered. The computation of the temperature in the components of the vehicle is illustrated. For this mainly local approaches for the classical and electronic components are used. Finally a new overall approach for the heat protection is explained where also detailed computations at the engine, at the exhaust system and at the transmission are integrated.

Content

1. Introduction
2. Theoretical fundamentals
3. Computational methods
4. Numerical simulation of the flow in and around the vehicle
5. Computation of the temperature in components
6. Overall approach for the heat protection

**Course: Thermal Solar Energy [2169472]****Coordinators:** R. Stieglitz**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 25 minutes

no tools or reference materials may be used during the exam

**Conditions**

Basics in heat and mass transfer, material science and fluid mechanics

**Recommendations**

desirable are reliable knowledge in physics in optics and thermodynamics

**Learning Outcomes**

The lecture elaborates the basics of the solar technology and the definition of the major wordings and its physical content such as radiation, thermal use, insulation etc.. Further the design of solar collectors for different purposes is discussed and analyzed. The functional principle of solar plants is elaborated before at the end the ways for solar climatization is discussed.

The aim of the course is to provide the basic physical principles and the derivation of key parameters for the individual solar thermal use. This involves in addition to the selective absorber, mirrors, glasses, and storage technology. In addition, a utilization of solar thermal energy means an interlink of the collector with a thermal-hydraulic circuit and a storage. The goal is to capture the regularities of linking to derive efficiency correlations as a function of their use and evaluate the performance of the entire system.

**Content**

Basics of thermal solar energy (radiation, heat conduction, storage, efficiency ...) Active and passive use of solar energy. Solar collectors (design types, efficiency, system technology). Solar plants (heliostats etc.). Solar climatization.

In detail:

- 1 Introduction to energy requirements and evaluation of the potential use of solar thermal energy.
  - 2 Primary energy sources SUN: sun, solar constant, radiation (direct, diffuse scattering, absorption, impact angle, radiation balance).
  - 3 Solar panels: schematic structure of a collector, fundamentals of efficiency, meaning of concentration and their limitations.
  - 4 Passive solar mechanisms: heat conduction in solids and gases, radiation heat transfer in transparent and opaque bodies, selective absorber - typical materials and manufacturing processes.
  - 5 Momentum and heat transport: basic equations of single and multiphase transport, calculation methods, stability limits.
- optional
- 6 Low temperature solar thermal systems: Collector variants, methods for system simulation, planning and dimensioning of systems, system design and arrest scenarios.
  - 6 High temperature solar thermal systems: solar towers and solar-farm concept, loss mechanisms, chimney power plants and energy production processes

end

- Memory: energy content, storage types, storage materials, cost
- Solar Air Conditioning: Cooling capacity determination, climate, solar cooling method and evaluation of air conditioning.

**Literature**

supply of lecture material in printed and electronic form

Stieglitz & Heinzel; Thermische Solarenergie -Grundlagen-Technologie- Anwendungen. Springer Vieweg Verlag. 711 Seiten. ISBN 978-3-642-29474-7

**Course: Thermal Turbomachines I [2169453]****Coordinators:** H. Bauer**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | en                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 min

no tools or reference materials may be used during the exam

**Conditions**

None.

**Recommendations**

It is a recommended lecture combination with 'Thermal Turbomachines II'.

**Learning Outcomes**

The students are able to explain and comment on the design and operation of thermal turbomachines in detail. Moreover, they can evaluate the range of applications for turbomachinery. Therefore, students are able to describe and analyse not only the individual components but also entire assemblies. The students can assess and evaluate the effects of physical, economical and ecological boundary conditions.

**Content**

Basic concepts of thermal turbomachinery

Steam Turbines - Thermodynamic process analysis

Gas Turbines - Thermodynamic process analysis

Combined cycle and cogeneration processes

Overview of turbomachinery theory and kinematics

Energy transfer process within a turbine stage

Types of turbines (presented through examples)

1-D streamline analysis techniques

3-D flow fields and radial momentum equilibrium in turbines

Compressor stage analysis and future trends in turbomachinery

**Literature**

Lecture notes (available via Internet)

Bohl, W.: Strömungsmaschinen, Bd. I, II; Vogel Verlag, 1990, 1991

Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993

Traupel, W.: Thermische Turbomaschinen Bd. I, II, Springer-Verlag, 1977, 1982

**Course: Thermal Turbomachines II [2170476]****Coordinators:** H. Bauer**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Summer term | en                   |

**Learning Control / Examinations**

oral (can only be taken in conjunction with 'Thermal Turbomachines I')  
 Duration: approx. 30 min (→ 1 hour including Thermal Turbomachines I)

Auxiliary: no tools or reference materials may be used during the exam

**Conditions**

None.

**Recommendations**

Recommended as lecture combination with 'Thermal Turbomachines I'.

**Learning Outcomes**

Based on the fundamental skills learned in 'Thermal Turbomachines I' the students have the ability to design turbines and compressors and to analyse the operational behavior of these machines.

**Content**

General overview, trends in design and development

Comparison turbine - compressor

Integrating resume of losses

Principal equations and correlations in turbine and compressor design, stage performance

Off-design performance of multi-stage turbomachines

Control system considerations for steam and gas turbines

Components of turbomachines

Critical components

Materials for turbine blades

Cooling methods for turbine blades (steam and air cooling methods)

Short overview of power plant operation

Combustion chamber and environmental issues

**Literature**

Course not packet

Bohl, W.: Strömungsmaschinen, Bd. I,II, Vogel Verlag 1990, 1991

Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993

Traupel, W.: Thermische Turbomaschinen, Bd. I,II, Springer-Verlag, 1977, 1982

## Course: Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises) [2193002]

**Coordinators:** H. Seifert, D. Cupid

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral examination (30 min)

### Conditions

- basic course in materials science and engineering
- physical chemistry

### Recommendations

none

### Learning Outcomes

The students know the heterogeneous phase equilibria of binary, ternary and multicomponent materials systems. They can analyze the thermodynamic properties of multiphase engineering materials and their reactions with gas and liquid phases.

### Content

1. Binary phase diagrams
2. Ternary phase diagrams
  - Complete solubility
  - Eutectic systems
  - Peritectic systems
  - Systems with transition reactions
  - Systems with intermetallic phases
3. Thermodynamics of solution phases
4. Materials reactions involving pure condensed phases and a gaseous phase
5. Reaction equilibria in systems containing components in condensed solutions
6. Thermodynamics of multicomponent multiphase materials systems
7. Calculation of Phase Diagrams (CALPHAD)

### Literature

1. Phase Equilibria, Phase Diagrams and Phase Transformations, Their Thermodynamic Basis; M. Hillert, University Press, Cambridge (2007)
2. Introduction to the Thermodynamics of Materials; D.R. Gaskell, Taylor & Francis (2008)

**Course: Tractors [2113080]****Coordinators:** M. Kremmer**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

**Conditions**

basic knowledge in mechanical engineering

**Learning Outcomes**

After completion of the course the Students know:

- important problems in agritechnological developments
- Customer requirements and their implementation in tractors
- Tractor technology in width and depth

**Content**

Tractors are one of the most underestimated vehicles in regard to performance und technics. Almost none vehicle is as multifunctional and fulfilled with high-tec as a tractor. Automatic guidance, special chassis suspension or special concepts of power trains are one of the topics where tractors are in leading position in technologies

During the lecture an overview about the design and construction and application area is given. A close look will be taken on the historical background, legal requirements, ways of development, agricultural organizations and the proces of development itself.

In detail the following topics will be dealt with:

- agricultural organization / legal requirements
- history of tractors
- tractor engineering
- tractor mechanics
- chassis suspension
- combustion engine
- transmission
- interfaces
- hydraulics
- wheels and tyres
- cabin
- electrics and electronics

**Literature**

- K.T. Renius: Traktoren - Technik und ihre Anwendung; DLG Verlag (Frankfurt), 1985
- E. Schilling: Landmaschinen - Lehr- und Handbuch für den Landmaschinenbau; Schilling-Verlag (Köln), 1960

**Course: Tribology [2181114]****Coordinators:** M. Scherge, M. Dienwiebel**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term |                      |

**Learning Control / Examinations**

oral examination (30 min)

no tools or reference materials

**Conditions**

None.

**Recommendations**

preliminary knowlegde in mathematics, mechanics and materials science

**Learning Outcomes**

The student can

- describe the fundamental friction and wear mechanisms, which occur in tribologically stressed systems.
- evaluate the friction and wear behavior of tribological systems.
- explain the effects of lubricants and their most important additives
- identify suitable approaches to optimize tribological systems.

**Content**

- Chapter 1: Friction Adhesion, geometrical and real area of contact, Friction experiments, friction powder, tribological stressing, environmental influences, tribological age, contact models, Simulation of contacts, roughness.
- Chapter 2: Wear, plastic deformation at the asperity level, dissipation modes, mechanical mixing, Dynamics of the third body, running-in, running- in dynamics, shear stress.
- Chapter 3: Lubrication, base oils, Stribeck plot, lubrication regimes (HD, EHD, mixed lubrication), additives, oil characterization, solid lubrication.

**Literature**

1. Fleischer, G. ; Gröger, H. ; Thum: Verschleiß und Zuverlässigkeit. 1. Auflage. Berlin : VEB-Verlag Technik, 1980
2. Persson, B.J.N.: Sliding Friction, Springer Verlag Berlin, 1998
3. M. Dienwiebel, and M. Scherge, Nanotribology in automotive industry, In:Fundamentals of Friction and Wear on the Nanoscale; Editors: E. Meyer and E. Gnecco, Springer, Berlin, 2007.
4. Scherge, M., Shakhvorostov, D., Pöhlmann, K.: Fundamental wear mechanism of metals. Wear 255, 395–400 (2003)
5. Shakhvorostov, D., Pöhlmann, K., Scherge, M.: An energetic approach to friction, wear and temperature. Wear 257, 124–130 (2004)

**Course: Turbine and compressor Design [2169462]****Coordinators:** H. Bauer, A. Schulz**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

Thermal Turbomachines I+II

**Learning Outcomes**

The students have the ability to:

- 
- describe special types of components, such as e.g. radial machines and transonic compressors
- explain and evaluate the operation of components and machines
- interpret and apply the the physical principles
- design individual components in a practical approach

**Content**

The lecture is intended to expand the knowledge from Thermal Turbomachines I+II.  
Thermal Turbomaschinen, general overview

Design of a turbomachine: Criteria and development

Radial machines

Transonic compressors

Combustion chambers

Multi-spool installations

**Literature**

Münzberg, H.G.: Gasturbinen - Betriebsverhalten und Optimierung, Springer Verlag, 1977

Traupel, W.: Thermische Turbomaschinen, Bd. I-II, Springer Verlag, 1977, 1982

**Course: Turbo Jet Engines [2170478]****Coordinators:** H. Bauer, A. Schulz**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

The students have the ability to:

- 
- compare the design concepts of modern jet engines
- analyse the operation of modern jet engines
- apply the thermodynamic and fluidmechanic basics of jet engines
- choose the main components intake, compressor, combustor, turbine and thrust nozzle based on given criteria
- comment on different methods for the reduction of pollutant emissions, noise and fuel consumption

**Content**

Introduction to jet engines and their components

Demands on engines and propulsive efficiency

Thermodynamic and gas dynamic fundamentals and design calculations

Components of air breathing engines

Jet engine design and development process

Engine and component design

Current developments in the jet engines industry

**Literature**

Hagen, H.: Fluggasturbinen und ihre Leistungen, G. Braun Verlag, 1982

Hünnecke, K.: Flugtriebwerke, ihre Technik und Funktion, Motorbuch Verlag, 1993

Saravanamuttoo, H.; Rogers, G.; Cohen, H.: Gas Turbine Theory, 5th Ed., 04/2001

Rolls-Royce: The Jet Engine, ISBN:0902121235, 2005

## Course: Tutorial for Heat Transfer in Nuclear Reactors [2189901]

**Coordinators:** X. Cheng

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 1            | 1              | Winter / Summer Term | en                   |

### Learning Control / Examinations

- Exam together with the course „Nuclear Thermal-Hydraulics“
- Results from the exercise with sub-channel analysis program

### Conditions

None.

### Learning Outcomes

The goal of the lecture is to

- Improve the understanding of the course „nuclear thermal-hydraulics“
- Demonstrate practical examples of flow and heat transfer in reactor core
- Exercise the application of a sub-channel program for reactor core design analysis

### Content

- About 5-7 exercises to calculate: heat source distribution, pressure drop, heat transfer, temperature distribution in reactor core, critical heat flux, natural convection capability etc.
- Exercise with sub-channel program

**Course: Metal Forming [2150681]****Coordinators:** T. Herlan**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The students

- are able to reflect the basics, forming processes, tools, Machines and equipment of metal forming in an integrated and systematic way.
- are capable to illustrate the differences between the forming processes, tools, machines and equipment with concrete examples and are qualified to analyze and assess them in terms of their suitability for the particular application.
- are also able to transfer and apply the acquired knowledge to other metal forming problems.

**Content**

At the beginning of the lecture the basics of metal forming are briefly introduced. The focus of the lecture is on massive forming (forging, extrusion, rolling) and sheet forming (car body forming, deep drawing, stretch drawing). This includes the systematic treatment of the appropriate metal forming Machines and the corresponding tool technology.

Aspects of tribology, as well as basics in material science and aspects of production planning are also discussed briefly. The plastic theory is presented to the extent necessary in order to present the numerical simulation method and the FEM computation of forming processes or tool design. The lecture will be completed by product samples from the forming technology.

The topics are as follows:

- Introduction and basics
- Hot forming
- Metal forming machines
- Tools
- Metallographic fundamentals
- Plastic theory
- Tribology
- Sheet forming
- Extrusion
- Numerical simulation

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

**Course: Vacuum and Tritium Technology [2190499]****Coordinators:** C. Day, B. Bornschein, D. Demange**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content**

**Course: Combustion diagnostics [2167048]****Coordinators:** R. Schießl, U. Maas**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

After completing this course students can:

- understand the specific requirements for diagnostic techniques in combustion applications.
- explain the physical fundamentals of diagnostic techniques, in particular of laser diagnostics.
- assess the potentials and the limits of the different diagnostic methods.

**Content**

Diagnostical methods: Laser induced fluorescence, Rayleigh-scattering, Raman-scattering  
Chemoluminescence.

Reduced description of combustion processes and measurements.

Discussion of the potential and limits of specific strategies in different combustion systems.

**Literature**

Lecture notes

A.C. Eckbreth, Laser Diagnostics for Combustion Temperature and Species,  
Abacus Press, 2nd ed. (1996)

W. Demtröder, Laser Spectroscopy: Basic Concepts and Instrumentation,  
Springer, 3rd ed., 2003

Hollas J.M. Modern Spectroscopy, Wiley, 3rd ed., 1996

K. Kohse-Höinghaus, J. B. Jeffries (ed.), Applied Combustion Diagnostics,  
Taylor and Francis

Atkins P., Paula, J., Physical Chemistry, 8th ed., Oxford University Press,  
2006

**Course: Behaviour Generation for Vehicles [2138336]****Coordinators:** C. Stiller, T. Dang**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes

no reference materials

**Conditions**

Fundamentals in measurement, system and control theory, e.g. from the lecture "Measurement and Control Systems"

**Learning Outcomes**

Modern vehicle control systems like ABS or ESP transform the intention of the driver into a corresponding behaviour of the vehicle. This is achieved by compensating disturbances like a varying traction for example. Within the recent years, vehicles have been increasingly equipped with sensors that gather information about the environment (Radar, Lidar and Video for example). This enables the vehicles to generate an 'intelligent' behaviour and transform this behaviour into control signals for actors. Several so called 'driver assistance systems' have already achieved remarkable improvements as far as comfort, safety and efficiency are concerned. But nevertheless, several decades of research will be required to achieve an automated behaviour with a performance equivalent to a human operator ('the driver'). The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Information technology, control theory and kinematic aspects are treated to provide a broad overview over vehicle guidance. Application examples from cutting-edge and future driver assistance systems illustrate the discussed subjects.

**Content**

1. Driver assistance systems
2. Driving comfort and safety
3. Vehicle dynamics
4. Path and trajectory planning
5. Path control
6. Collision avoidance

**Literature**

TBA

## Course: Failure of Structural Materials: Fatigue and Creep [2181715]

**Coordinators:** O. Kraft, P. Gumbsch, P. Gruber  
**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral exam 30 minutes  
 no tools or reference materials

### Conditions

compulsory preconditions: none

### Recommendations

preliminary knowlegde in mathematics, mechanics and materials science

### Learning Outcomes

The student

- has the basic understanding of mechanical processes to explain the relationships between externally applied load and materials strength.
- can describe the main empirical materials models for fatigue and creep and can apply them.
- has the physical understanding to describe and explain phenomena of failure.
- can use statistical approaches for reliability predictions.
- can use its acquired skills, to select and develop materials for specific applications.

### Content

1 Fatigue

1.1 Introduction

1.2 Statistical Aspects

1.3 Lifetime

1.4 Fatigue Mechanisms

1.5 Material Selection

1.6 Thermomechanical Loading

1.7 Notches and Shape Optimization

1.8 Case Study: ICE-Desaster

2 Creep

2.1 Introduction

2.2 High Temperature Plasticity

2.3 Phänomenological DEscription of Creep

2.4 Creep Mechanisms

2.5 Alloying Effects

### Literature

- Engineering Materials, M. Ashby and D.R. Jones (2nd Edition, Butterworth-Heinemann, Oxford, 1998); worth reading, relatively simple but comprehensive
- Mechanical Behavior of Materials, Thomas H. Courtney (2nd Edition, McGraw Hill, Singapur); classic on the mechanical behavior of materials, extensive and good
- Bruchvorgänge in metallischen Werkstoffen, D. Aurich (Werkstofftechnische Verlagsgesellschaft Karlsruhe), relatively simple but yet comprehensive overview of metallic materials
- Fatigue of Materials, Subra Suresh (2nd Edition, Cambridge University Press); standard work on fatigue, all classes of materials, extensive, for beginners and advanced student

## Course: Failure of structural materials: deformation and fracture [2181711]

**Coordinators:** P. Gumbsch, O. Kraft, D. Weygand

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

no tools or reference materials

### Conditions

compulsory preconditions: none

### Recommendations

preliminary knowlegde in mathematics, mechanics and materials science

### Learning Outcomes

The student

- has the basic understanding of mechanical processes to explain the relationship between externally applied load and materials strength.
- can explain the foundation of linear elastic fracture mechanics and is able to determine if this concept can be applied to a failure by fracture.
- can decribe the main empirical materials models for deformation and fracture and can apply them.
- has the physical understanding to describe and explain phenomena of failure.

### Content

1. Introduction
2. linear elasticity
3. classification of stresses
4. Failure due to plasticity
  - tensile test
  - dislocations
  - hardening mechanisms
  - guidelines for dimensioning
5. composite materials
6. fracture mechanics
  - hypotheses for failure
  - linear elasic fracture mechanics
  - crack resitance
  - experimental measurement of fracture toughness
  - defect measurement
  - crack propagation
  - application of fracture mechanics
  - atomistics of fracture

**Literature**

- Engineering Materials, M. Ashby and D.R. Jones (2nd Edition, Butterworth-Heinemann, Oxford, 1998); worth reading, relatively simple but comprehensive
- Mechanical Behavior of Materials, Thomas H. Courtney (2nd Edition, McGraw Hill, Singapur); classic on the mechanical behavior of materials, extensive and good
- Bruchvorgänge in metallischen Werkstoffen, D. Aurich (Werkstofftechnische Verlagsgesellschaft Karlsruhe), relatively simple but yet comprehensive overview of metallic materials

## Course: Gear Cutting Technology [2149655]

**Coordinators:** M. Klaiber

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The assessment is carried out as an oral examination. The examination is offered every winter semester in agreement with the Lecturer.

### Conditions

None

### Recommendations

None

### Learning Outcomes

The students . . .

- can describe the basic terms of gears and are able to explain the imparted basics of the gearwheel and gearing theory.
- are able to specify the different manufacturing processes and machine technologies for producing gears. Furthermore they are able to explain the functional principles and the dis-/advantages of these manufacturing processes.
- can apply the basics of the gearing theory and manufacturing processes on new problems.
- are able to read and interpret measuring records for gears.
- are able to make an appropriate selection of a process based on a given application
- can describe the entire process chain for the production of toothed components and their respective influence on the resulting workpiece properties.

### Content

Based on the gearing theory, manufacturing processes and machine technologies for producing gears, the needs of modern gear manufacturing will be discussed in the lecture. For this purpose, various processes for various gear types are taught which represent the state of the art in practice today. A classification in soft and hard machining and furthermore in cutting and non-cutting technologies will be made. For comprehensive understanding the processes, machine technologies, tools and applications of the manufacturing of gears will be introduced and the current developments presented. For assessment and classification of the applications and the performance of the technologies, the methods of mass production and manufacturing defects will be discussed. Sample parts, reports from current developments in the field of research and an excursion to a gear manufacturing company round out the lecture.

The following topics will be covered:

- Sample applications
- Basics of gearing geometry
- Need of gearboxes
- Soft machining processes
- Hardening processes
- Hard machining processes
- Bevel gear production
- Measurement and testing

- Manufacturing of gearbox components
- Special gearings

**Media**

Lecture slides will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Slides

**Remarks**

None

## Course: Virtual Engineering (Specific Topics) [3122031]

**Coordinators:** J. Ovtcharova

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 2              | Summer term | en                   |

### Learning Control / Examinations

Oral examination

Duration: 20 min

Auxiliary Means: none

### Conditions

None

### Recommendations

None

### Learning Outcomes

The students will acquire an introduction in Product Lifecycle Management (PLM) and understand the application of PLM in Virtual Engineering.

Furthermore, they will have an extensive knowledge of the data models, the specific modules and functions of CAD systems. They will have an awareness of the IT background of CAx systems, as well as the integration problems and possible approaches.

Students will receive an overview of various CAE analysis methods along with the application possibilities, basic conditions and limitations. They will know the different function of preprocessor, solver and postprocessor of CAE systems.

The students will get to know the definition of virtual reality how the stereoscopic effect occurs and which technologies can be used to simulate this effect.

Moreover, they will know which validation tests can be carried through in the product development process with the aid of a virtual mock-up (VMU) and what's the difference between a VMU, a physical mock-up (PMU) and a virtual prototype (VP).

### Content

The lecture presents the informational interrelationship required for understanding the virtual product development process. For this purpose, an emphasis and focus will be placed on IT-systems used in the industrial sector as support for the process chain of virtual engineering:

- Product Lifecycle Management refers to the entire lifecycle of the product, beginning with the concept phase up through disassembling and recycling.
- CAx-systems for the virtual product development allow the modeling of a digital product in regards to design, construction, manufacturing and maintenance.
- Validation Systems allow the checking of the product in regard to static, dynamics, safety and build ability.
- The corresponding models can be visualized in Virtual Reality Systems, from single parts up through a complete assembly.
- Virtual Prototypes combine CAD-data as well as information about the remaining characteristics of the components and assembly groups for immersive visualisation, functionality tests and functional validations in the VR/AR/MR environment.
- Integrated Virtual Product Development exemplified the product development process from the point of view of Virtual Engineering.

The goal of the lecture is to clarify the relationship between construction and validation operations through the usage of virtual prototypes and VR/AR/MR visualisation techniques in connection with PDM/PLM-systems.

### Literature

Lecture slides

## Course: Virtual Engineering I [2121352]

**Coordinators:** J. Ovtcharova

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 5              | Winter term | de                   |

### Learning Control / Examinations

Depending on choice according to actual version of study regulations

Duration: 30 min

Auxiliary Means: none

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

The students can:

- rename and explain the basic methods of virtual engineering and the typical problems in product development.
- associate the methods and problems of the corresponding phases of the product life cycle and derive the necessary interfaces.
- select the appropriate IT systems for given problems and evaluate their suitability for the support of management's approach PLM.
- apply CAD/CAx/PLM-Systems using simple exercises.

### Content

The lecture presents the informational interrelationship required for understanding the virtual product development process. For this purpose, an emphasis and focus will be placed on IT-systems used in the industrial sector as support for the process chain of virtual engineering:

- Product Lifecycle Management refers to the entire lifecycle of the product, beginning with the concept phase up through disassembling and recycling.
- CAx-systems for the virtual product development allow the modeling of a digital product in regards to design, construction, manufacturing and maintenance.
- Validation Systems allow the checking of the product in regard to static, dynamics, safety and build ability.

The goal of the lecture is to clarify the relationship between construction and validation operations through the usage of virtual prototypes and VR/AR/MR visualisation techniques in connection with PDM/PLM-systems. This will be achieved through an introduction to each particular system along with praxis-oriented exercises.

### Literature

Lecture slides

**Course: Virtual Engineering II [2122378]****Coordinators:** J. Ovtcharova**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Depending on choice according to actual version of study regulations

Auxiliary Means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students will be able to:

- describe virtual reality, how the stereoscopic effect occurs and compare the technologies to simulate this effect.
- describe how to model a scene in VR, store the VR graph on a computer and explain the inner workings of the VR pipeline for visualizing the scene.
- name various systems for interacting with the VR scene and assess the advantages and disadvantages of various manipulation and tracking devices.
- compare validation tests that can be carried through in the product development process with the aid of a virtual mock-up (VMU) and describe the difference between a VMU, a physical mock-up (PMU) and a virtual prototype (VP).
- point out the vision of an integrated virtual product development and which challenges need to be resolved towards that vision.

**Content**

The lecture presents the informational interrelationship required for understanding the virtual product development process. For this purpose, an emphasis and focus will be placed on IT-systems used in the industrial sector as support for the process chain of virtual engineering:

- The corresponding models can be visualized in Virtual Reality Systems, from single parts up through a complete assembly.
- Virtual Prototypes combine CAD-data as well as information about the remaining characteristics of the components and assembly groups for immersive visualisation, functionality tests and functional validations in the VR/AR/MR environment.
- Integrated Virtual Product Development exemplified the product development process from the point of view of Virtual Engineering.

The goal of the lecture is to clarify the relationship between construction and validation operations through the usage of virtual prototypes and VR/AR/MR visualisation techniques in connection with PDM/PLM-systems. This will be achieved through an introduction to each particular IT-system along with praxis-oriented exercises.

**Literature**

Lecture slides

## Course: Heat and mass transfer [2165512]

**Coordinators:** H. Bockhorn, U. Maas

**Part of the modules:** Compulsory Elective Subject PEK (p. 43)[MSc-Modul PEK, WPF PEK], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject E+U (p. 38)[MSc-Modul E+U, WPF E+U], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

written (in winter- or summerterm)

duration: 3 hours

additives: non-programmable calculator, 2 DIN-A4-pages individual formulary

### Conditions

None.

### Recommendations

- Basic studies in Mechanical Engineering or Chemical Engineering with completed intermediate diploma
- Lectures in Thermodynamics, Fluid Dynamics and Higher Mathematics

### Learning Outcomes

Students know about the contents of Heat and mass transfer.

### Content

- Stationäre und instationäre Wärmeleitung in homogenen und Verbund-Körpern; Platten, Rohrschalen und Kugelschalen
- Molekulare, äquimolare und einseitige Diffusion in Gasen; Analogie der Stoffdiffusion zur Wärmeleitung
- Konvektiver, erzwungener Wärmeübergang in durchströmten Rohren/Kanälen sowie bei überströmten Platten und umströmten Profilen
- Konvektiver Stoffübergang, Stoff-/Wärmeübergangs-Analogie
- Mehrphasiger konvektiver Wärmeübergang (Kondensation, Verdampfung)
- Strahlungswärmeaustausch von Festkörpern und Gasen

### Literature

- Bockhorn, H.; Vorlesungsskript "Wärme- und Stoffübertragung"
- Baehr, H.-D., Stephan, K.: "Wärme- und Stoffübertragung", Springer Verlag, 1993
- Incropera, F., DeWitt, F.: "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 1996
- Bird, R., Stewart, W., Lightfoot, E.: "Transport Phenomena", John Wiley & Sons, 1960

**Course: Heatpumps [2166534]****Coordinators:** H. Wirbser, U. Maas**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The attendance of this course enables students to:

- 
- describe the setup and the working principle of heat pumps.
- specify the various types of heat pumps.
- analyse the energetic requirements.
- asses the advantages and drawbacks of heat pumps as heating system.

**Content**

The aim of this lecture is to promote heat pumps as heating systems for small an medium scale facilities and to discuss their advantages as well as their drawbacks. After considering the actual energy situation and the political requirements the different aspects of heat pumps are elucidated. The requirements concerning heat sources, the different components and the various types of heat pumps are discussed. In addition ecological and economical aspects are taken into consideration. The coupling of heat pumps with heat accumulators in heating systems will also be part of the lecture.

**Literature**

Vorlesungsunterlagen

Bach, K.: Wärmepumpen, Bd. 26 Kontakt und Studium, Lexika Verlag, 1979

Kirn, H., Hadenfeldt, H.: Wärmepumpen, Bd. 1: Einführung und Grundlagen, Verlag C. F. Müller, 1987

von Cube, H.L.: Lehrbuch der Kältetechnik, Verlag C.F. Müller, Karlsruhe, 1975.

von Cube, H.L., Steimle,F.: Wärmepumpen, Grunglagen und Praxis VDI-Verlag, Düsseldorf, 1978.

## Course: Heat Transfer in Nuclear Reactors [2189907]

**Coordinators:** X. Cheng

**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)], Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

oral examination; duration: 20 minutes

### Conditions

None.

### Learning Outcomes

This lecture is focused on students of mechanical engineering and chemical engineering in bachelor or master degree courses. The students learn important processes and methods of heat transfer nuclear reactors. Exercises with numerical simulationa programs will enhance the understanding.

### Content

1. Overview of nuclear systems
2. Design tasks and design criteria of nuclear thermal-hydraulics
3. Heat release and distribution in nuclear reactors
4. Heat transfer process in nuclear reactors
5. Temperature distribution in coolant and structural materials
6. Pressure drops in nuclear systems
7. Flow stability of nuclear systems
8. Critical flow under accident conditions
9. Natural circulation and passive safety systems
10. Methodologies of thermal-hydraulic design

### Literature

1. W. Oldekop, Einführung in die Kernreaktor und Kernkraftwerkstechnik, Verlag Karl Thiemeig, München, 1975
2. L.S. Tong, J. Weisman, Thermal-hydraulics of pressurized water reactors, American Nuclear Society, La Grande Park, Illinois, USA
3. R.T. Lahey, F.J. Moody, The Thermal-Hydraulics of a Boiling Water Nuclear Reactor, 2nd edition, ANS, La Grande Park, Illinois, USA, 1993

## Course: Probability Theory and Statistics [0186000]

**Coordinators:** D. Hug

**Part of the modules:** Mathematic Methods (p. 57)[MSc-Modul 08, MM], Compulsory Elective Subject FzgT (p. 39)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Subject M+M (p. 41)[MSc-Modul M+M, WPF M+M], Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 5            | 3              | Winter / Summer Term |                      |

### Learning Control / Examinations

written exam (180 minutes)

### Conditions

None.

### Learning Outcomes

Students

- know the basic descriptive measures of distributions, and they are able to compute these in simple examples
- know the basic probabilistic models, concepts and methods, and they can apply these in simple examples
- know basic ideas of statistical inference, and they can set up estimators and confidence intervals in simple cases

### Content

This course provides an introduction to basic concepts, methods and procedures in probability theory and statistics. It starts with descriptive statistics, explains the foundations of probability theory and treats statistical inference towards the end. Probability theory develops and applies mathematical models for phenomena of the real world that involve randomness, which are also of interest in their own right.

Probability theory constitutes the main part of the course. The task of descriptive statistics is to describe, order and collect data which arise from experiments. A presentation of these data can be given, for instance, by means of graphics or statistical characteristics (arithmetic mean, median, empirical variance etc.). Statistical inference is concerned with exploring in how far specific results of experiments are valid in greater generality, hence with inference from real data.

Content: Descriptive statistics

Events

Probability Spaces

Elements of Combinatorial Theory

Random Variables and their Distributions (discrete and continuous)

Conditional probability

Stochastic Independence

Descriptive Measures of Distributions

Generating Function and Laplace-Transform

Limit Theorems

Random Numbers and Simulation

Basic Problems of Statistics

Point Estimation

Confidence Regions

Statistical Tests

**Course: Hydrogen Technologies [2170495]****Coordinators:** T. Jordan**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

Auxiliary: no tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

The course content is the cross-cutting issue of hydrogen as energy carrier. The basic hydrogen technologies will be presented in order to analyse and substantiate the idea of a hydrogen economy. The physical properties of hydrogen will be introduced. The production, distribution, storage and applications are explained. The latter comprise hydrogen utilization in combustion engines and in fuel cells. The safety aspects will be treated as a cross-cutting issue by comparing with hazards of conventional energy carriers.

**Content**

Basic concepts

Production

Transport and storage

Application

Safety aspects

**Literature**

Ullmann's Encyclopedia of Industrial Chemistry

<http://www.hysafe.net/BRHS>

**Course: Wave Propagation [2161219]****Coordinators:** W. Seemann**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral

30 minutes (optional subject), 20 minutes (major subject)

no means

**Conditions**

Vibration theory

**Learning Outcomes**

The course gives an introduction into wave propagation phenomena. This contains both one-dimensional continua (beams, rods, strings) as well as two- and three-dimensional continua. Initial condition problems are treated. Fundamental effects like phase velocity, group velocity or dispersion are explained. Wave propagation is used to show the limits of structural models like beams. In addition surface waves and acoustic waves are covered.

**Content**

Wave propagation in strings and rods, d'Alembert's solution, initial value problem, boundary conditions, excitation at the boundary, energy transport, wave propagation in beams, Bernoulli-Euler beams, group velocity, beams with changing cross-section, reflexion and transmission, Timoshenko beam theory, wave propagation in membranes and plates, acoustic waves, reflexion and refraction, spherical waves, s- and p-waves in elastic media, reflexion and transmission at bounding surfaces, surface waves

**Literature**

P. Hagedorn and A. Dasgupta: Vibration and waves in continuous mechanical systems. Wiley, 2007.

**Course: Material Analysis [2174586]****Coordinators:** J. Gibmeier**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination

duration: 20 - 30 minutes

no auxillary resources

**Conditions**

obligation: Material Science I/II

**Learning Outcomes**

The students have basic knowledge about methods of material analysis. They have a basic understanding to transfer this basic knowledge on problems in engineering science. Furthermore, the students have the ability to describe technical material by its microscopic and submicroscopic structure

**Content**

The following methods will be introduced within this module:

microscopic methods: optical microscopy, electron microscopy (SEM/TEM), atomic force microscopy

material and microstructure analyses by means of X-ray, neutron and electron beams

spectroscopic methods

**Literature**

lecture notes (will be provided at the beginning of the lecture)

literature will be quoted at the beginning of the lecture

**Course: Materials for Lightweight Construction [2174574]****Coordinators:** K. Weidenmann**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 - 30 Min

none

**Conditions**

Werkstoffkunde I/II (recommended)

**Learning Outcomes**

The students are capable to name different lightweight materials and can describe their composition, properties and fields of application. They can describe the hardening mechanisms of lightweight materials and can transfer this knowledge to applied problems.

The students can apply basic mechanical models of composites and can depict differences in the mechanical properties depending on composition and structure. The students can describe the basic principle of hybrid material concepts and can judge their advantages in comparison to bulk materials. The students can name special materials for lightweight design and depict differences to conventional materials. The students have the ability to present applications for different lightweight materials and can balance reasons for their use.

**Content**

Introduction

Constructive, production-oriented and material aspects of lightweight construction

Aluminium-based alloys

Aluminium wrought alloys

Aluminium cast alloys

Magnesium-based alloys

Magnesium wrought alloys

Magnesium cast alloys

Titanium-based alloys

Titanium wrought alloys

Titanium cast alloys

High-strength steels

High-strength structural steels

Heat-treatable and hardenable steels

Composites - mainly PMC

Matrices

Reinforcements

**Literature**

Presentation slides and additional lecture notes are handed out during the lecture, additional literature recommendations given

## Course: Materials modelling: dislocation based plasticity [2182740]

**Coordinators:** D. Weygand

**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

None.

### Recommendations

preliminary knowlegde in mathematics, physics and materials science

### Learning Outcomes

The student

- has the basic understanding of the physical basics to describe dislocations and their interaction with point, line and area defects.
- can apply modelling approaches for dislocation based plasticity.
- can explain discrete methods for modelling of microstructural evolution processes.

### Content

1. Introduction
2. elastic fields of dislocations
3. slip, crystallography
4. equations of motion of dislocations
  - a) fcc
  - b) bcc
5. interaction between dislocations
6. discrete dislocation dynamics in two dimensions
7. discrete dislocation dynamics in three dimensions
8. continuum description of dislocations
9. microstructure evolution: grain growth
  - a) physical basis: small/large angle boundaries
  - b) interaction between dislocations and GBs
- 10) Monte Carlo methods in micro structure evolution

### Literature

1. D. Hull and D.J. Bacon, Introduction to Dislocations, Oxford Pergamon 1994
2. J.P. Hirth and J. Lothe: Theory of dislocations, New York Wiley 1982. (oder 1968)
3. J. Friedel, Dislocations, Pergamon Oxford 1964.
4. V. Bulatov, W. Cai, Computer Simulations of Dislocations, Oxford University Press 2006
5. A.S. Argon, Strengthening mechanisms in crystal plasticity, Oxford materials.

**Course: Wind and Hydropower [2157451]****Coordinators:** M. Gabi, N. Lewald**Part of the modules:** Lectures in English (M.Sc.) (p. 62)[Englischsprachige Veranstaltungen (M.Sc.)]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

**Learning Control / Examinations**

Written or Oral exam (according notice),  
 oral 30 minutes,  
 written 1,5 hours,  
 no means

**Conditions**

2157451 can not be combined with the courses 2157432 (Hydraulic Machinery 1) and 23381 (Windpower)

**Recommendations**

Fluid Mechanics

**Learning Outcomes**

The students know basic fundamentals for the use of wind- and hydropower.

**Content**

Wind- and Hydropower fundamental lecture. Introduction in the basics of fluid machinery.

**Windpower:**

Basic knowledge for the use of wind power for electricity, complemented by historical development, basic knowledge on wind systems and alternative renewable energies. Global and local wind systems as well as their measurement and energy content are dedicated. Aerodynamic basics and connections of wind-power plants and/or their profiles, as well as electrical system of the wind-power plants are described. Fundamental generator technology over control and controlling of the energy transfer.

Finally the current economic, ecological and legislations boundary conditions for operating wind-power plants are examined. An overview of current developments like super-grids and visions of the future of the wind power utilization will be given.

**Hydropower:**

Basic knowledge for the use of hydropower for electricity, complemented by historical development. Description of typical hydropower systems.

Introduction in the technology and different types of water turbines. Calculation of the energy conversion of typical hydropower systems.

**Literature**

- Erich Hau, Windkraftanlagen, Springer Verlag.
- J. F. Douglas et al., Fluid Mechanics, Pearson Education.
- Pfeleiderer, Petermann, Strömungsmaschinen, Springer Verlag.
- Sandor O. Pálffy et al., Wasserkraftanlagen, Expert Verlag

## Course: Scientific computing for Engineers [2181738]

**Coordinators:** D. Weygand, P. Gumbsch

**Part of the modules:** Compulsory Elective Subject ThM (p. 45)[MSc-Modul ThM, WPF ThM], Compulsory Elective Subject General Mechanical Engineering (p. 36)[MSc-Modul AM, WPF AM], Elective Subject (p. 47)[MSc-Modul 04, WF], Compulsory Elective Subject W+S (p. 46)[MSc-Modul W+S, WPF W+S]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

compulsory preconditions: none

### Learning Outcomes

The student can

- apply the programming language C++ for scientific computing in the field of materials science
- adapt programs for use on parallel platforms
- choose suitable numerical methods for the solution of differential equations.

### Content

1. Introduction: why scientific computing
2. computer architectures
3. Introduction to Unix/Linux
4. Foundations of C++
  - \* programm organization
  - \* data types, operator, control structures
  - \* dynamic memory allocation
  - \* functions
  - \* class
  - \* OpenMP parallelization
5. numeric /algorithms
  - \* finite differences
  - \* MD simulations: 2nd order differential equations
  - \* algorithms for particle simulations
  - \* solver for linear systems of eqns.

### Literature

1. C++: Einführung und professionelle Programmierung; U. Breymann, Hanser Verlag München
2. C++ and object-oriented numeric computing for Scientists and Engineers, Daoqui Yang, Springer Verlag.
3. The C++ Programming Language, Bjarne Stroustrup, Addison-Wesley
4. Die C++ Standardbibliothek, S. Kuhlins und M. Schader, Springer Verlag

Numerik:

1. Numerical recipes in C++ / C / Fortran (90), Cambridge University Press
2. Numerische Mathematik, H.R. Schwarz, Teubner Stuttgart
3. Numerische Simulation in der Moleküldynamik, Griebel, Knapek, Zumbusch, Caglar, Springer Verlag

**Course: Two-Phase Flow and Heat Transfer [2169470]****Coordinators:** T. Schulenberg, M. Wörner**Part of the modules:** Elective Subject (p. 47)[MSc-Modul 04, WF]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

Bachelor

**Learning Outcomes**

The students can describe two-phase flows with heat transfer as phenomena occurring in steam generators and condensers (e.g. in power stations or refrigerators). They can distinguish different flow regimes and transitions and apply two-phase flow models. The students are qualified to explain the characteristics of different flow examples (e.g. pressure drop of two phase flows, pool boiling, forced convective boiling, condensation) and can analyze two-phase flow instabilities.

**Content**

- Examples for technical applications
- Definitions and averaging of two-phase flows
- Flow regimes and transitions
- Two-phase models
- Pressure drop of two phase flows
- Pool boiling
- Forced convective boiling
- Condensation
- Two-phase flow instabilities

**Literature**

lecture notes

## 5 Major Fields

**SP 01: Advanced Mechatronics**

| ID      | Cat   | Course  | Lecturer                      | h | CP | Term |
|---------|-------|---|-------------------------------|---|----|------|
| 2105012 | K     | Adaptive Control Systems (p. 478)   | G. Bretthauer                 | 2 | 4  | W    |
| 2106004 | K     | Computational Intelligence I (p. 541)   | G. Bretthauer, R. Mikut       | 2 | 4  | S    |
| 2106020 | K     | Computational Intelligence III (p. 543)   | R. Mikut                      | 2 | 4  | S    |
| 2105011 | K     | Introduction into Mechatronics (p. 556)   | G. Bretthauer, A. Albers      | 3 | 6  | W    |
| 2138326 | K     | Measurement II (p. 711)   | C. Stiller                    | 2 | 4  | S    |
| 2162216 | K     | Computerized Multibody Dynamics (p. 791)  | W. Seemann                    | 2 | 4  | S    |
| 2161219 | K     | Wave Propagation (p. 875)   | W. Seemann                    | 2 | 4  | W    |
| 2147175 | E (P) | CAE-Workshop (p. 536)   | A. Albers, Assistenten        | 3 | 4  | W/S  |
| 2105015 | E     | Computational Intelligence II (p. 542)  | G. Bretthauer, R. Mikut       | 2 | 4  | W    |
| 2137309 | E     | Digital Control (p. 546)  | M. Knoop                      | 2 | 4  | W    |
| 2113816 | E     | Vehicle Mechatronics I (p. 585)   | D. Ammon                      | 2 | 4  | W    |
| 2138340 | E     | Automotive Vision (p. 587)  | C. Stiller, M. Lauer          | 2 | 4  | S    |
| 2161252 | E     | Advanced Methods in Strength of Materials (p. 640)                              | T. Böhlke                     | 4 | 4  | W    |
| 2105022 | E     | Information Processing in Mechatronic Systems (p. 652)                          | M. Kaufmann                   | 2 | 4  | W    |
| 2118183 | E     | IT-Fundamentals of Logistics (p. 662)   | F. Thomas                     | 2 | 4  | S    |
| 2138341 | E     | Cognitive Automobiles - Laboratory (p. 668)                                     | C. Stiller, M. Lauer, B. Kitt | 2 | 4  | S    |
| 2146190 | E     | Lightweight Engineering Design (p. 672)   | A. Albers, N. Burkardt        | 2 | 4  | S    |
| 2137308 | E     | Machine Vision (p. 686)   | C. Stiller, M. Lauer          | 4 | 8  | W    |
| 2161206 | E     | Mathematical Methods in Dynamics (p. 696)                                       | C. Proppe                     | 2 | 5  | W    |
| 2161254 | E     | Mathematical Methods in Strength of Materials (p. 697)                          | T. Böhlke                     | 3 | 5  | W    |
| 2181710 | E     | Mechanics in Microtechnology (p. 706)   | P. Gruber, C. Greiner         | 2 | 4  | W    |
| 2145180 | E     | Methodic Development of Mechatronic systems (p. 713)                            | A. Albers, W. Burger          | 2 | 4  | W    |
| 2142881 | E     | Microactuators (p. 717)   | M. Kohl                       | 2 | 4  | S    |
| 2141865 | E     | Novel actuators and sensors (p. 733)  | M. Kohl, M. Sommer            | 4 | 6  | W    |
| 2147161 | E     | Intellectual Property Rights and Strategies in Industrial Companies (p. 744)    | F. Zacharias                  | 2 | 4  | W/S  |
| 2137306 | E (P) | Lab Computer-aided methods for measurement and control (p. 762)                 | C. Stiller, P. Lenz           | 3 | 4  | W    |
| 2138336 | E     | Behaviour Generation for Vehicles (p. 862)                                      | C. Stiller, T. Dang           | 2 | 4  | S    |
| 2141864 | E     | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I (p. 529)   | A. Guber                      | 2 | 4  | W    |
| 2142883 | E     | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II (p. 530)  | A. Guber                      | 2 | 4  | S    |
| 2142879 | E     | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III (p. 531) | A. Guber                      | 2 | 4  | S    |
| 2150904 | E     | Automated Manufacturing Systems (p. 514)  | J. Fleischer                  | 6 | 8  | S    |
| 24152   | E     | Robotics I – Introduction to robotics (p. 796)                                  | R. Dillmann, S. Schmidt-Rohr  | 2 | 3  | W    |
| 24659   | E     | Human-Machine-Interaction (p. 708)  | M. Beigl, Takashi Miyaki      | 2 | 3  | S    |

| ID      | Cat | Course   | Lecturer                  | h | CP | Term |
|---------|-----|--|---------------------------|---|----|------|
| 23109   | E   | Signals and Systems (p. 810)                             | F. Puente, F. Puente León | 2 | 3  | W    |
| 2106033 | E   | System Integration in Micro- and Nanotechnology (p. 835) | U. Gengenbach             | 2 | 4  | S    |
| 24600   | E   | Multilingual Human-Machine Communication (p. 729)        | T. Schultz, F. Putze      | 4 | 6  | S    |

**Conditions:****Recommendations:** Recommended courses:

- 2105011 Einführung in die Mechatronik
- 2141861 Grundlagen der Mikrosystemtechnik I
- 2142874 Grundlagen der Mikrosystemtechnik II
- 2105014 Mechatronik-Praktikum

**Learning Outcomes:** The Advanced Mechatronics offers a broad, multidisciplinary body of knowledge. It qualifies graduates to solve essential mechatronic questions. In particular the following disciplines are covered by the major Advanced Mechatronics:

- Control theory
- Measurement technology and signal processing
- Mathematical methods

Students of the major Advanced Mechatronics know the future-oriented procedures. They are able to creatively solve complex interdisciplinary questions by applying the latest computer-assisted mathematical methods.

**Remarks:**

**SP 02: Powertrain Systems**

| ID      | Cat | Course   | Lecturer                         | h | CP | Term |
|---------|-----|--|----------------------------------|---|----|------|
| 2113077 | K   | Drive Train of Mobile Machines (p. 489)                                      | M. Geimer, M. Scherer            | 3 | 4  | W    |
| 2146180 | K   | Powertrain Systems Technology A: Automotive Systems (p. 491)                 | A. Albers, S. Ott                | 2 | 4  | S    |
| 2145150 | K   | Powertrain Systems Technology B: Stationary Machinery (p. 492)               | A. Albers, S. Ott                | 2 | 4  | W    |
| 2163111 | K   | Dynamics of the Automotive Drive Train (p. 550)                              | A. Fidlin                        | 4 | 5  | W    |
| 2105012 | E   | Adaptive Control Systems (p. 478)  | G. Bretthauer                    | 2 | 4  | W    |
| 2145181 | E   | Applied Tribology in Industrial Product Development (p. 487)                 | A. Albers, W. Burger             | 2 | 4  | W    |
| 2162235 | E   | Introduction into the multi-body dynamics (p. 557)                           | W. Seemann                       | 3 | 5  | S    |
| 2117500 | E   | Energy efficient intralogistic systems (p. 568)                              | F. Schönung                      | 2 | 4  | W    |
| 2118183 | E   | IT-Fundamentals of Logistics (p. 662)  | F. Thomas                        | 2 | 4  | S    |
| 2145184 | E   | Leadership and Product Development (p. 680)                                  | A. Ploch                         | 2 | 4  | W    |
| 2161224 | E   | Machine Dynamics (p. 691)  | C. Proppe                        | 3 | 5  | S    |
| 2162220 | E   | Machine Dynamics II (p. 692)   | C. Proppe                        | 2 | 4  | W    |
| 2145180 | E   | Methodic Development of Mechatronic systems (p. 713)                         | A. Albers, W. Burger             | 2 | 4  | W    |
| 2141865 | E   | Novel actuators and sensors (p. 733)   | M. Kohl, M. Sommer               | 4 | 6  | W    |
| 2147161 | E   | Intellectual Property Rights and Strategies in Industrial Companies (p. 744) | F. Zacharias                     | 2 | 4  | W/S  |
| 2145182 | E   | Project management in Global Product Engineering Structures (p. 782)         | P. Gutzmer                       | 2 | 4  | W    |
| 2150683 | E   | Control Technology (p. 822)  | C. Gönnheimer                    | 2 | 4  | S    |
| 2146193 | E   | Strategic Product Planning (p. 825)  | A. Siebe                         | 2 | 4  | S    |
| 2146192 | E   | Sustainable Product Engineering (p. 834)                                     | K. Ziegahn                       | 2 | 4  | S    |
| 2181711 | E   | Failure of structural materials: deformation and fracture (p. 865)           | P. Gumbsch, O. Kraft, D. Weygand | 2 | 4  | W    |
| 2133103 | E   | Fundamentals of Combustion Engines I (p. 629)                                | H. Kubach, T. Koch               | 3 | 4  | W    |
| 2134131 | E   | Fundamentals of Combustion Engines II (p. 630)                               | H. Kubach, T. Koch               | 3 | 4  | S    |
| 2181114 | E   | Tribology (p. 853)   | M. Scherge, M. Dienwiebel        | 4 | 8  | W    |
| 2113072 | E   | Development of Oil-Hydraulic Powertrain Systems (p. 780)                     | G. Geerling, I. Ays              | 2 | 4  | W    |
| 23321   | E   | Hybrid and Electric Vehicles (p. 641)  | M. Doppelbauer, M. Schiefer      | 3 | 4  | W    |

**Conditions:****Recommendations:** Recommended Courses:

2147175 CAE-Workshop

**Learning Outcomes:** The students know and understand the technical and physical basics and systematic connections of drive systems. The lecture deals vehicle drive systems as well as drive systems for stationary and mobile work machines. They are able to choose, describe and use complex dimensioning- and design methods for drive systems under consideration of the interactions of the system.

**Remarks:**

**SP 03: Human Factors Engineering**

| ID      | Cat   | Course  | Lecturer        | h | CP | Term |
|---------|-------|---|-----------------|---|----|------|
| 2109035 | KP    | Human Factors Engineering I (p. 496)                                  | B. Deml         | 2 | 4  | W    |
| 2109036 | KP    | Human Factors Engineering II (p. 498)                                 | B. Deml         | 2 | 4  | W    |
| 2109033 | K (P) | Human Factors Lab (p. 499)  | B. Deml         | 2 | 4  | W    |
| 2109042 | E     | Introduction to Industrial Production Economics (p. 647)              | S. Dürrschnabel | 2 | 4  | W    |
| 2110037 | E     | Occupational Safety and Environmental Protection (in German) (p. 648) | R. von Kiparski | 2 | 4  | S    |
| 2145184 | E     | Leadership and Product Development (p. 680)                           | A. Ploch        | 2 | 4  | W    |
| 2110017 | E     | Leadership and Conflict Management (in German) (p. 689)               | H. Hatzl        | 2 | 4  | S    |
| 2109034 | E     | Planning of Assembly Systems (in German) (p. 747)                     | E. Haller       | 2 | 4  | W    |
| 2110046 | E     | Productivity Management in Production Systems (p. 776)                | S. Stowasser    | 2 | 4  | S    |
| 2117061 | E     | Safety Engineering (p. 809)   | H. Kany         | 2 | 4  | W    |
| 2146179 | E     | Technical Design in Product Development (p. 841)                      | M. Schmid       | 2 | 4  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** The students acquire in the compulsory core subjects profound knowledge about the scientific theories, principles and methods of Human Factors Engineering. The students can afterwards analyse, evaluate and design works tasks, work processes and work systems in consideration of technical, organisational as well as social conditions. The students are able to configure a work system in order to realise enduring and personality forming working conditions for the employees. The students deepen in the elective courses specific fields of application. Afterwards they are able to analyse, evaluate and solve problems of this specific field of application.

After completion this module, the students are able

- to describe the goals of Human Factors Engineering,
- to describe the prevailing requirements of the working world and the thereof resulting fields of application of Human Factors Engineering and to give examples,
- to describe and to apply basic theories, methods and tools for the different fields of application of Human Factors Engineering,
- to evaluate micro as well as macro work systems, to identify problems in a work system and to organise and configure a work system.

**Remarks:**

**SP 04: Automation Technology**

| ID      | Cat    | Course   | Lecturer  | h | CP | Term |
|---------|--------|--|---|---|----|------|
| 2105012 | K      | Adaptive Control Systems (p. 478)  | G. Bretthauer                                   | 2 | 4  | W    |
| 2106005 | K      | Automation Systems (p. 516)  | M. Kaufmann                                     | 2 | 4  | S    |
| 2106004 | K      | Computational Intelligence I (p. 541)  | G. Bretthauer, R. Mikut                         | 2 | 4  | S    |
| 2105015 | K      | Computational Intelligence II (p. 542)                                       | G. Bretthauer, R. Mikut                         | 2 | 4  | W    |
| 2106020 | K      | Computational Intelligence III (p. 543)                                      | R. Mikut  | 2 | 4  | S    |
| 2137309 | K      | Digital Control (p. 546)   | M. Knoop  | 2 | 4  | W    |
| 2105011 | K      | Introduction into Mechatronics (p. 556)                                      | G. Bretthauer, A. Albers                        | 3 | 6  | W    |
| 2105024 | K      | Modern Control Concepts I (p. 726)   | L. Gröll  | 2 | 4  | W    |
| 2147175 | E (P)  | CAE-Workshop (p. 536)  | A. Albers, Assistenten                          | 3 | 4  | W/S  |
| 2113816 | E      | Vehicle Mechatronics I (p. 585)  | D. Ammon  | 2 | 4  | W    |
| 2137308 | E      | Machine Vision (p. 686)  | C. Stiller, M. Lauer                            | 4 | 8  | W    |
| 2105014 | E (P)  | Laboratory mechatronics (p. 707)   | A. Albers, G. Bretthauer, C. Proppe, C. Stiller | 3 | 4  | W    |
| 2138326 | E      | Measurement II (p. 711)  | C. Stiller                                      | 2 | 4  | S    |
| 2147161 | E      | Intellectual Property Rights and Strategies in Industrial Companies (p. 744) | F. Zacharias                                    | 2 | 4  | W/S  |
| 2137306 | E (P)  | Lab Computer-aided methods for measurement and control (p. 762)              | C. Stiller, P. Lenz                             | 3 | 4  | W    |
| 2150683 | E      | Control Technology (p. 822)  | C. Gönzheimer                                   | 2 | 4  | S    |
| 2161219 | E      | Wave Propagation (p. 875)  | W. Seemann                                      | 2 | 4  | W    |
| 2138336 | E      | Behaviour Generation for Vehicles (p. 862)                                   | C. Stiller, T. Dang                             | 2 | 4  | S    |
| 2123375 | EM (P) | Virtual Reality Laboratory (p. 871)  | J. Ovtcharova                                   | 3 | 4  | W/S  |
| 2149902 | E      | Machine Tools and Industrial Handling (p. 880)                               | J. Fleischer                                    | 6 | 8  | W    |
| 2150904 | E      | Automated Manufacturing Systems (p. 514)                                     | J. Fleischer                                    | 6 | 8  | S    |
| 2106033 | E      | System Integration in Micro- and Nanotechnology (p. 835)                     | U. Gengenbach                                   | 2 | 4  | S    |
| 24600   | E      | Multilingual Human-Machine Communication (p. 729)                            | T. Schultz, F. Putze                            | 4 | 6  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** The Automation Engineering offers both theoretical foundations and practical knowledge in the field of automation. Students can select, apply and enhance existing methods. The main focus of the major is on

- Applied control engineering
- Automation
- Examples of field applications

Students of Automation Engineering are qualified to master complex challenges of the future. They are able to apply their profound knowledge and the future-oriented methods independent of a particular application field.

**Remarks:**

**SP 05: Calculation Methods in Mechanical Engineering**

| ID      | Cat   | Course  | Lecturer                          | h | CP | Term |
|---------|-------|---|-----------------------------------|---|----|------|
| 2162235 | K     | Introduction into the multi-body dynamics (p. 557)              | W. Seemann                        | 3 | 5  | S    |
| 2161252 | K     | Advanced Methods in Strength of Materials (p. 640)              | T. Böhlke                         | 4 | 4  | W    |
| 2157441 | K     | Computational Methods in Fluid Mechanics (p. 739)               | F. Magagnato                      | 2 | 4  | W    |
| 2181740 | E     | Atomistic simulations and molecular dynamics (p. 500)           | P. Gumbsch                        | 2 | 4  | S    |
| 2147175 | E (P) | CAE-Workshop (p. 536)   | A. Albers, Assistenten            | 3 | 4  | W/S  |
| 2106004 | E     | Computational Intelligence I (p. 541)                           | G. Bretthauer, R. Mikut           | 2 | 4  | S    |
| 2105015 | E     | Computational Intelligence II (p. 542)                          | G. Bretthauer, R. Mikut           | 2 | 4  | W    |
| 2106020 | E     | Computational Intelligence III (p. 543)                         | R. Mikut                          | 2 | 4  | S    |
| 2162282 | E     | Introduction to the Finite Element Method (p. 551)              | T. Böhlke                         | 4 | 5  | S    |
| 2146190 | E     | Lightweight Engineering Design (p. 672)                         | A. Albers, N. Burkardt            | 2 | 4  | S    |
| 2161214 | E     | Vibration of continuous systems (p. 673)                        | H. Hetzler                        | 2 | 4  | S    |
| 2161224 | E     | Machine Dynamics (p. 691)                                       | C. Proppe                         | 3 | 5  | S    |
| 2162220 | E     | Machine Dynamics II (p. 692)                                    | C. Proppe                         | 2 | 4  | W    |
| 2161206 | E     | Mathematical Methods in Dynamics (p. 696)                       | C. Proppe                         | 2 | 5  | W    |
| 2161254 | E     | Mathematical Methods in Strength of Materials (p. 697)          | T. Böhlke                         | 3 | 5  | W    |
| 2162241 | E     | Mathematical methods of vibration theory (p. 698)               | W. Seemann                        | 3 | 5  | S    |
| 2162280 | E     | Mathematical Methods in Structural Mechanics (p. 700)           | T. Böhlke                         | 3 | 5  | S    |
| 2134134 | E     | Analysis tools for combustion diagnostics (p. 712)              | U. Wagner                         | 2 | 4  | S    |
| 2183702 | E     | Modelling of Microstructures (p. 719)                           | A. August, B. Nestler, D. Weygand | 3 | 5  | W    |
| 2183703 | E     | Modelling and Simulation (p. 724)                               | B. Nestler, P. Gumbsch            | 3 | 5  | W/S  |
| 2162344 | E     | Nonlinear Continuum Mechanics (p. 735)                          | T. Böhlke                         | 2 | 5  | S    |
| 2161250 | E     | Computational Mechanics I (p. 793)                              | T. Böhlke, T. Langhoff            | 4 | 6  | W    |
| 2162296 | E     | Computational Mechanics II (p. 794)                             | T. Böhlke, T. Langhoff            | 4 | 6  | S    |
| 2114095 | E     | Simulation of Coupled Systems (p. 811)                          | M. Geimer                         | 4 | 4  | S    |
| 2161217 | E (P) | Mechatronic Softwaretools (p. 819)                              | C. Proppe                         | 2 | 4  | W    |
| 2117095 | E     | Basics of Technical Logistics (p. 626)                          | M. Mittwollen, Madzharov          | 4 | 6  | W    |
| 2161212 | E     | Vibration Theory (p. 840)                                       | A. Fidlin                         | 3 | 5  | W    |
| 2117059 | EM    | Mathematical models and methods for Production Systems (p. 702) | K. Furmans, J. Stoll              | 4 | 6  | W    |
| 2163111 | E     | Dynamics of the Automotive Drive Train (p. 550)                 | A. Fidlin                         | 4 | 5  | W    |
| 2163113 | E     | Theory of Stability (p. 821)                                    | A. Fidlin                         | 4 | 6  | W    |
| 2162247 | E     | Introduction to Nonlinear Vibrations (p. 562)                   | A. Fidlin                         | 4 | 7  | S    |
| 2161241 | E (P) | Schwingungstechnisches Praktikum (p. 807)                       | H. Hetzler, A. Fidlin             | 3 | 3  | S    |
| 2117096 | E     | Elements of Technical Logistics (p. 565)                        | M. Mittwollen, Madzharov          | 3 | 4  | W    |

| ID      | Cat   | Course   | Lecturer                 | h | CP | Term |
|---------|-------|--|--------------------------|---|----|------|
| 2162207 | E     | Dynamics of mechanical Systems with tribological Contacts (p. 549)       | H. Hetzler               | 2 | 4  | W    |
| 2154432 | E     | Mathematical Methods in Fluid Mechanics (p. 699)                         | A. Class, B. Frohnapfel  | 2 | 4  | S    |
| 2154430 | E     | Introduction to modeling of aerospace systems (p. 558)                   | G. Schlöffel             | 2 | 4  | S    |
| 2117097 | E     | Elements of Technical Logistics and Project (p. 566)                     | M. Mittwollen, Madzharov | 4 | 6  | W    |
| 2157445 | E     | Computational methods for the heat protection of a full vehicle (p. 845) | H. Reister               | 2 | 4  | W    |
| 2162225 | E     | Experimental Dynamics (p. 576)   | A. Fidlin, H. Hetzler    | 3 | 5  | S    |
| 2157444 | E (P) | Introduction to numerical fluid dynamics (p. 560)                        | B. Pritz                 | 2 | 4  | W    |
| 2154200 | E     | (p. 603)   | F. Magagnato             | 2 | 4  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** Goal of this unit is to understand several methods in different disciplines to derive mathematical models. The students can do this exemplarily for some disciplines and apply the corresponding methods. The aim is not to be able use special software packages but to understand the principles on which these methods are based.

**Remarks:**

**SP 06: Computational Mechanics**

| ID      | Cat    | Course  | Lecturer               | h | CP | Term |
|---------|--------|---|------------------------|---|----|------|
| 2161226 | K      | Introduction to numerical mechanics (p. 559)  | E. Schnack             | 3 | 5  | W    |
| 2161250 | K      | Computational Mechanics I (p. 793)  | T. Böhlke, T. Langhoff | 4 | 6  | W    |
| 2157441 | K      | Computational Methods in Fluid Mechanics (p. 739)   | F. Magagnato           | 2 | 4  | W    |
| 2162216 | E      | Computerized Multibody Dynamics (p. 791)  | W. Seemann             | 2 | 4  | S    |
| 2182735 | E      | Application of advanced programming languages in mechanical engineering (p. 495)                  | D. Weygand             | 2 | 4  | S    |
| 2181740 | E      | Atomistic simulations and molecular dynamics (p. 500)   | P. Gumbsch             | 2 | 4  | S    |
| 2153405 | E      | Finite Difference Methods for numerical solution of thermal and fluid dynamical problems (p. 545) | C. Günther             | 2 | 4  | W    |
| 2162282 | E      | Introduction to the Finite Element Method (p. 551)  | T. Böhlke              | 4 | 5  | S    |
| 2182732 | E      | Introduction to Theory of Materials (p. 554)  | M. Kamlah              | 2 | 4  | S    |
| 2183716 | E (P)  | FEM Workshop – constitutive laws (p. 589)   | K. Schulz, D. Weygand  | 2 | 4  | W/S  |
| 2154431 | E      | Finite Volume Methods for Fluid Flow (p. 595)   | C. Günther             | 2 | 4  | S    |
| 2181720 | E      | Foundations of nonlinear continuum mechanics (p. 623)   | M. Kamlah              | 2 | 4  | W    |
| 2162240 | E      | Mathematical Foundation for Computational Mechanics (p. 695)                                      | E. Schnack             | 2 | 4  | S    |
| 2161983 | E      | Mechanics of laminated composites (p. 704)  | E. Schnack             | 2 | 4  | W    |
| 2167523 | E      | Modeling of Thermodynamical Processes (p. 723)  | R. Schießl, U. Maas    | 3 | 6  | W/S  |
| 2162298 | E      | Numerical mechanics for industrial applications (p. 738)  | E. Schnack             | 3 | 5  | S    |
| 2154449 | E      | Numerical Simulation of Turbulent Flows (p. 742)  | G. Grötzbach           | 3 | 4  | S    |
| 2162344 | E      | Nonlinear Continuum Mechanics (p. 735)  | T. Böhlke              | 2 | 5  | S    |
| 2162246 | E      | Computational Dynamics (p. 789)   | C. Proppe              | 2 | 4  | S    |
| 2162256 | E      | Computational Vehicle Dynamics (p. 790)   | C. Proppe              | 2 | 4  | S    |
| 2162296 | E      | Computational Mechanics II (p. 794)   | T. Böhlke, T. Langhoff | 4 | 6  | S    |
| 2161217 | EM (P) | Mechatronic Softwaretools (p. 819)  | C. Proppe              | 2 | 4  | W    |
| 2169458 | E      | Numerical simulation of reacting two phase flows (p. 741)   | R. Koch                | 2 | 4  | W    |
| 2183721 | E      | High Performance Computing (p. 638)   | B. Nestler, M. Selzer  | 3 | 5  | W    |
| 2130934 | E      | Numerical Modeling of Multiphase Flows (p. 740)   | M. Wörner              | 2 | 4  | S    |
| 2157444 | E (P)  | Introduction to numerical fluid dynamics (p. 560)   | B. Pritz               | 2 | 4  | W    |

**Conditions:** Either course no. 2161226 or course no. 2161250 can be chosen.

**Recommendations:**

**Learning Outcomes:** The module offers a wide interdisciplinary education of the students in the areas which are summarized internationally under the concept 'Computational Mechanics':

\* Continuum modelling (in structural mechanics, material theory, dynamics, fluid mechanics and thermodynamics)

\* Numerical mathematics

### \* Informatics

Students know the procedures oriented to the future of modern engineering. They have the ability for individual, creative solutions of complicated problems with numerical means and take into account the interaction with neighboring fields.

#### **Remarks:**

**SP 08: Dynamics and Vibration Theory**

| ID      | Cat   | Course   | Lecturer               | h | CP | Term |
|---------|-------|--|------------------------|---|----|------|
| 2162235 | K     | Introduction into the multi-body dynamics (p. 557)                 | W. Seemann             | 3 | 5  | S    |
| 2161224 | K     | Machine Dynamics (p. 691)  | C. Proppe              | 3 | 5  | S    |
| 2161212 | K     | Vibration Theory (p. 840)  | A. Fidlin              | 3 | 5  | W    |
| 2163113 | K     | Theory of Stability (p. 821)                                       | A. Fidlin              | 4 | 6  | W    |
| 2162247 | K     | Introduction to Nonlinear Vibrations (p. 562)                      | A. Fidlin              | 4 | 7  | S    |
| 2147175 | E (P) | CAE-Workshop (p. 536)  | A. Albers, Assistenten | 3 | 4  | W/S  |
| 2146190 | E     | Lightweight Engineering Design (p. 672)                            | A. Albers, N. Burkardt | 2 | 4  | S    |
| 2162220 | E     | Machine Dynamics II (p. 692)                                       | C. Proppe              | 2 | 4  | W    |
| 2162246 | E     | Computational Dynamics (p. 789)                                    | C. Proppe              | 2 | 4  | S    |
| 2162256 | E     | Computational Vehicle Dynamics (p. 790)                            | C. Proppe              | 2 | 4  | S    |
| 2162216 | E     | Computerized Multibody Dynamics (p. 791)                           | W. Seemann             | 2 | 4  | S    |
| 2161241 | E (P) | Schwingungstechnisches Praktikum (p. 807)                          | H. Hetzler, A. Fidlin  | 3 | 3  | S    |
| 2161217 | E (P) | Mechatronic Softwaretools (p. 819)                                 | C. Proppe              | 2 | 4  | W    |
| 2161219 | E     | Wave Propagation (p. 875)  | W. Seemann             | 2 | 4  | W    |
| 2138336 | E     | Behaviour Generation for Vehicles (p. 862)                         | C. Stiller, T. Dang    | 2 | 4  | S    |
| 2161214 | E     | Vibration of continuous systems (p. 673)                           | H. Hetzler             | 2 | 4  | S    |
| 2163111 | E     | Dynamics of the Automotive Drive Train (p. 550)                    | A. Fidlin              | 4 | 5  | W    |
| 2162207 | E     | Dynamics of mechanical Systems with tribological Contacts (p. 549) | H. Hetzler             | 2 | 4  | W    |
| 2154430 | E     | Introduction to modeling of aerospace systems (p. 558)             | G. Schlöffel           | 2 | 4  | S    |
| 2154437 | E     | Hydrodynamic Stability: From Order to Chaos (p. 645)               | A. Class               | 2 | 4  | S    |
| 2162225 | E     | Experimental Dynamics (p. 576)                                     | A. Fidlin, H. Hetzler  | 3 | 5  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** The students know different methods which may be applied for the analysis or investigation of vibration problems. They are able to treat one or multiple degrees of freedom systems as well as vibrating continua. The goal is to establish a chain from physical modeling via mathematical solution to an interpretation of the results. Based on the courses which are chosen the knowledge has emphasis on theoretical investigations, approximation methods or experimental methods.

**Remarks:**

**SP 09: Dynamic Machine Models**

| ID      | Cat   | Course  | Lecturer                     | h | CP | Term |
|---------|-------|---|------------------------------|---|----|------|
| 2162235 | K     | Introduction into the multi-body dynamics (p. 557)                        | W. Seemann                   | 3 | 5  | S    |
| 2161212 | K     | Vibration Theory (p. 840)   | A. Fidlin                    | 3 | 5  | W    |
| 2118078 | K     | Logistics - organisation, design and control of logistic systems (p. 682) | K. Furmans                   | 4 | 6  | S    |
| 2105012 | E     | Adaptive Control Systems (p. 478)   | G. Bretthauer                | 2 | 4  | W    |
| 2146180 | E     | Powertrain Systems Technology A: Automotive Systems (p. 491)              | A. Albers, S. Ott            | 2 | 4  | S    |
| 2147175 | E (P) | CAE-Workshop (p. 536)   | A. Albers, Assistenten       | 3 | 4  | W/S  |
| 2117500 | E     | Energy efficient intralogistic systems (p. 568)                           | F. Schönung                  | 2 | 4  | W    |
| 2113807 | E     | Handling Characteristics of Motor Vehicles I (p. 580)                     | H. Unrau                     | 2 | 4  | W    |
| 2114838 | E     | Handling Characteristics of Motor Vehicles II (p. 581)                    | H. Unrau                     | 2 | 4  | S    |
| 2113806 | E     | Vehicle Comfort and Acoustics I (p. 582)                                  | F. Gauterin                  | 2 | 4  | W    |
| 2114825 | E     | Vehicle Comfort and Acoustics II (p. 583)                                 | F. Gauterin                  | 2 | 4  | S    |
| 2146190 | E     | Lightweight Engineering Design (p. 672)                                   | A. Albers, N. Burkardt       | 2 | 4  | S    |
| 2161206 | E     | Mathematical Methods in Dynamics (p. 696)                                 | C. Proppe                    | 2 | 5  | W    |
| 2114095 | E     | Simulation of Coupled Systems (p. 811)                                    | M. Geimer                    | 4 | 4  | S    |
| 2138336 | E     | Behaviour Generation for Vehicles (p. 862)                                | C. Stiller, T. Dang          | 2 | 4  | S    |
| 2122378 | E     | Virtual Engineering II (p. 870)   | J. Ovtcharova                | 3 | 4  | S    |
| 2118087 | EM    | Selected Applications of Technical Logistics (p. 503)                     | M. Mittwollen, Madzharov     | 3 | 4  | S    |
| 2118088 | EM    | Selected Applications of Technical Logistics and Project (p. 504)         | M. Mittwollen, Madzharov     | 4 | 6  | S    |
| 2163111 | E     | Dynamics of the Automotive Drive Train (p. 550)                           | A. Fidlin                    | 4 | 5  | W    |
| 2163113 | E     | Theory of Stability (p. 821)  | A. Fidlin                    | 4 | 6  | W    |
| 2162247 | E     | Introduction to Nonlinear Vibrations (p. 562)                             | A. Fidlin                    | 4 | 7  | S    |
| 2161241 | E (P) | Schwingungstechnisches Praktikum (p. 807)                                 | H. Hetzler, A. Fidlin        | 3 | 3  | S    |
| 2162241 | E     | Mathematical methods of vibration theory (p. 698)                         | W. Seemann                   | 3 | 5  | S    |
| 2161214 | E     | Vibration of continuous systems (p. 673)                                  | H. Hetzler                   | 2 | 4  | S    |
| 2162207 | E     | Dynamics of mechanical Systems with tribological Contacts (p. 549)        | H. Hetzler                   | 2 | 4  | W    |
| 24152   | E     | Robotics I – Introduction to robotics (p. 796)                            | R. Dillmann, S. Schmidt-Rohr | 2 | 3  | W    |
| 2162225 | E     | Experimental Dynamics (p. 576)  | A. Fidlin, H. Hetzler        | 3 | 5  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** The students know the methods to derive physical and mathematical models in different disciplines. They know that such models are necessary to investigate such systems theoretically and to simulate their behaviour prior to a physical realization.

**Remarks:**

**SP 10: Engineering Design**

| ID      | Cat   | Course   | Lecturer  | h | CP | Term |
|---------|-------|--|---|---|----|------|
| 2146180 | K     | Powertrain Systems Technology A: Automotive Systems (p. 491)         | A. Albers, S. Ott                               | 2 | 4  | S    |
| 2145150 | K     | Powertrain Systems Technology B: Stationary Machinery (p. 492)       | A. Albers, S. Ott                               | 2 | 4  | W    |
| 2146190 | K     | Lightweight Engineering Design (p. 672)                              | A. Albers, N. Burkardt                          | 2 | 4  | S    |
| 2145181 | E     | Applied Tribology in Industrial Product Development (p. 487)         | A. Albers, W. Burger                            | 2 | 4  | W    |
| 2117064 | E     | Application of technical logistics in modern crane systems (p. 493)  | M. Golder                                       | 2 | 4  | W    |
| 2113079 | E     | Design and Development of Mobile Machines (p. 512)                   | M. Geimer, J. Siebert                           | 2 | 4  | W    |
| 2147175 | E (P) | CAE-Workshop (p. 536)  | A. Albers, Assistenten                          | 3 | 4  | W/S  |
| 2149657 | E     | Manufacturing Technology (p. 591)                                    | V. Schulze, F. Zanger                           | 6 | 8  | W    |
| 2113805 | E     | Automotive Engineering I (p. 616)                                    | F. Gauterin, H. Unrau                           | 4 | 8  | W    |
| 2113814 | E     | Fundamentals for Design of Motor-Vehicles Bodies I (p. 632)          | H. Bardehle                                     | 1 | 2  | W    |
| 2114840 | E     | Fundamentals for Design of Motor-Vehicles Bodies II (p. 633)         | H. Bardehle                                     | 1 | 2  | S    |
| 2113812 | E     | Fundamentals in the Development of Commercial Vehicles I (p. 634)    | J. Zürn   | 1 | 2  | W    |
| 2114844 | E     | Fundamentals in the Development of Commercial Vehicles II (p. 635)   | J. Zürn   | 1 | 2  | S    |
| 2113810 | E     | Fundamentals of Automobile Development I (p. 636)                    | R. Frech  | 1 | 2  | W    |
| 2114842 | E     | Fundamentals of Automobile Development II (p. 637)                   | R. Frech  | 1 | 2  | S    |
| 2174571 | E     | Design with Plastics (p. 671)  | M. Liedel                                       | 2 | 4  | S    |
| 2145184 | E     | Leadership and Product Development (p. 680)                          | A. Ploch  | 2 | 4  | W    |
| 2110017 | E     | Leadership and Conflict Management (in German) (p. 689)              | H. Hatzl  | 2 | 4  | S    |
| 2105014 | E (P) | Laboratory mechatronics (p. 707)                                     | A. Albers, G. Bretthauer, C. Proppe, C. Stiller | 3 | 4  | W    |
| 2145180 | E     | Methodic Development of Mechatronic systems (p. 713)                 | A. Albers, W. Burger                            | 2 | 4  | W    |
| 2109028 | E     | Production Management I (p. 768)                                     | P. Stock  | 2 | 4  | W    |
| 2145182 | E     | Project management in Global Product Engineering Structures (p. 782) | P. Gutzmer                                      | 2 | 4  | W    |
| 2149667 | E     | Quality Management (p. 785)  | G. Lanza  | 2 | 4  | W    |
| 2117061 | E     | Safety Engineering (p. 809)  | H. Kany   | 2 | 4  | W    |
| 2146193 | E     | Strategic Product Planning (p. 825)                                  | A. Siebe  | 2 | 4  | S    |
| 2146192 | E     | Sustainable Product Engineering (p. 834)                             | K. Ziegahn                                      | 2 | 4  | S    |
| 2158107 | E     | Technical Acoustics (p. 836)   | M. Gabi   | 2 | 4  | S    |
| 2146179 | E     | Technical Design in Product Development (p. 841)                     | M. Schmid                                       | 2 | 4  | S    |
| 2174574 | E     | Materials for Lightweight Construction (p. 877)                      | K. Weidenmann                                   | 2 | 4  | S    |
| 2149902 | E     | Machine Tools and Industrial Handling (p. 880)                       | J. Fleischer                                    | 6 | 8  | W    |
| 2161229 | E     | Designing with numerical methods in product development (p. 547)     | E. Schnack                                      | 2 | 4  | W    |
| 2113072 | E     | Development of Oil-Hydraulic Powertrain Systems (p. 780)             | G. Geerling, I. Ays                             | 2 | 4  | W    |

## 5 MAJOR FIELDS

---

| ID      | Cat | Course   | Lecturer                | h | CP | Term |
|---------|-----|--|-------------------------|---|----|------|
| 2150601 | E   | Integrative Strategies in Production and Development of High Performance Cars (p. 656) | K. Schlichtenmayer      | 2 | 4  | S    |
| 2113809 | E   | Automotive Engineering I (p. 517)  | F. Gauterin, M. Gießler | 4 | 8  | W    |

**Conditions:** The courses [2113805] and [2113809] can not be combined within this major field.

**Recommendations:** 2147175 CAE-Workshop  
2105014 Mechatronik - Workshop

**Learning Outcomes:** The students are able to transfer their knowledge und abilities in product engineering to mechanical systems in research and industrial practice.

**Remarks:**

**SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics**

| ID      | Cat | Course   | Lecturer                | h | CP | Term |
|---------|-----|--|-------------------------|---|----|------|
| 2113806 | K   | Vehicle Comfort and Acoustics I (p. 582)                     | F. Gauterin             | 2 | 4  | W    |
| 2114856 | K   | Vehicle Ride Comfort & Acoustics I (p. 859)                  | F. Gauterin             | 2 | 4  | S    |
| 2114825 | K   | Vehicle Comfort and Acoustics II (p. 583)                    | F. Gauterin             | 2 | 4  | S    |
| 2114857 | K   | Vehicle Ride Comfort & Acoustics II (p. 860)                 | F. Gauterin             | 2 | 4  | S    |
| 2158107 | K   | Technical Acoustics (p. 836)                                 | M. Gabi                 | 2 | 4  | S    |
| 2105012 | E   | Adaptive Control Systems (p. 478)                            | G. Bretthauer           | 2 | 4  | W    |
| 2146180 | E   | Powertrain Systems Technology A: Automotive Systems (p. 491) | A. Albers, S. Ott       | 2 | 4  | S    |
| 2161216 | E   | Wave propagation (p. 561)                                    | W. Seemann              | 2 | 4  | W    |
| 2114850 | E   | Global vehicle evaluation within virtual road test (p. 608)  | B. Schick               | 2 | 4  | S    |
| 2113807 | E   | Handling Characteristics of Motor Vehicles I (p. 580)        | H. Unrau                | 2 | 4  | W    |
| 2114838 | E   | Handling Characteristics of Motor Vehicles II (p. 581)       | H. Unrau                | 2 | 4  | S    |
| 2113816 | E   | Vehicle Mechatronics I (p. 585)                              | D. Ammon                | 2 | 4  | W    |
| 2138340 | E   | Automotive Vision (p. 587)                                   | C. Stiller, M. Lauer    | 2 | 4  | S    |
| 2114835 | E   | Automotive Engineering II (p. 617)                           | F. Gauterin, H. Unrau   | 2 | 4  | S    |
| 2114855 | E   | Automotive Engineering II (p. 518)                           | F. Gauterin, M. Gießler | 2 | 4  | S    |
| 2153425 | E   | Industrial aerodynamics (p. 646)                             | T. Breitling            | 2 | 4  | W    |
| 2146190 | E   | Lightweight Engineering Design (p. 672)                      | A. Albers, N. Burkardt  | 2 | 4  | S    |
| 2145180 | E   | Methodic Development of Mechatronic systems (p. 713)         | A. Albers, W. Burger    | 2 | 4  | W    |
| 2105024 | E   | Modern Control Concepts I (p. 726)                           | L. Gröll                | 2 | 4  | W    |
| 2162246 | E   | Computational Dynamics (p. 789)                              | C. Proppe               | 2 | 4  | S    |
| 2162256 | E   | Computational Vehicle Dynamics (p. 790)                      | C. Proppe               | 2 | 4  | S    |
| 2162216 | E   | Computerized Multibody Dynamics (p. 791)                     | W. Seemann              | 2 | 4  | S    |
| 2138336 | E   | Behaviour Generation for Vehicles (p. 862)                   | C. Stiller, T. Dang     | 2 | 4  | S    |
| 2161219 | E   | Wave Propagation (p. 875)                                    | W. Seemann              | 2 | 4  | W    |

**Conditions:** The courses [2114835] and [2114855] can not be combined within this major field

The courses [2113806] and [2114856] can not be combined within this major field

The courses [2114825] and [2114857] can not be combined within this major field

**Recommendations:** Recommended courses:

- 2162235 Introduction into the multi-body dynamics
- 2161212 Vibration Theory

**Learning Outcomes:** The student

- knows and understands the dynamic characteristics of vehicles, owing to the construction and design tokens,
- knows and understands especially the factors being relevant for comfort and acoustics,
- is capable of fundamentally evaluating and rating handling characteristics.

**Remarks:**

**SP 12: Automotive Technology**

| ID      | Cat   | Course  | Lecturer                   | h | CP | Term |
|---------|-------|---|----------------------------|---|----|------|
| 2113805 | KP    | Automotive Engineering I (p. 616)   | F. Gauterin, H. Unrau      | 4 | 8  | W    |
| 2113809 | KP    | Automotive Engineering I (p. 517)   | F. Gauterin, M. Gießler    | 4 | 8  | W    |
| 2146180 | E     | Powertrain Systems Technology A: Automotive Systems (p. 491)                                  | A. Albers, S. Ott          | 2 | 4  | S    |
| 2114850 | E     | Global vehicle evaluation within virtual road test (p. 608)                                   | B. Schick                  | 2 | 4  | S    |
| 2113807 | E     | Handling Characteristics of Motor Vehicles I (p. 580)   | H. Unrau                   | 2 | 4  | W    |
| 2114838 | E     | Handling Characteristics of Motor Vehicles II (p. 581)  | H. Unrau                   | 2 | 4  | S    |
| 2113806 | E     | Vehicle Comfort and Acoustics I (p. 582)  | F. Gauterin                | 2 | 4  | W    |
| 2114856 | E     | Vehicle Ride Comfort & Acoustics I (p. 859)   | F. Gauterin                | 2 | 4  | S    |
| 2114825 | E     | Vehicle Comfort and Acoustics II (p. 583)   | F. Gauterin                | 2 | 4  | S    |
| 2114857 | E     | Vehicle Ride Comfort & Acoustics II (p. 860)  | F. Gauterin                | 2 | 4  | S    |
| 2113816 | E     | Vehicle Mechatronics I (p. 585)   | D. Ammon                   | 2 | 4  | W    |
| 2138340 | E     | Automotive Vision (p. 587)  | C. Stiller, M. Lauer       | 2 | 4  | S    |
| 2114835 | E     | Automotive Engineering II (p. 617)  | F. Gauterin, H. Unrau      | 2 | 4  | S    |
| 2114855 | E     | Automotive Engineering II (p. 518)  | F. Gauterin, M. Gießler    | 2 | 4  | S    |
| 2134138 | E     | Fundamentals of catalytic exhaust gas aftertreatment (p. 619)                                 | E. Lox                     | 2 | 4  | S    |
| 2114845 | E     | Basics and Methods for Integration of Tires and Vehicles (p. 586)                             | G. Leister                 | 2 | 4  | S    |
| 2113814 | E     | Fundamentals for Design of Motor-Vehicles Bodies I (p. 632)                                   | H. Bardehle                | 1 | 2  | W    |
| 2114840 | E     | Fundamentals for Design of Motor-Vehicles Bodies II (p. 633)                                  | H. Bardehle                | 1 | 2  | S    |
| 2113812 | E     | Fundamentals in the Development of Commercial Vehicles I (p. 634)                             | J. Zürn                    | 1 | 2  | W    |
| 2114844 | E     | Fundamentals in the Development of Commercial Vehicles II (p. 635)                            | J. Zürn                    | 1 | 2  | S    |
| 2113810 | E     | Fundamentals of Automobile Development I (p. 636)   | R. Frech                   | 1 | 2  | W    |
| 2114842 | E     | Fundamentals of Automobile Development II (p. 637)  | R. Frech                   | 1 | 2  | S    |
| 2146190 | E     | Lightweight Engineering Design (p. 672)   | A. Albers, N. Burkardt     | 2 | 4  | S    |
| 2115808 | E (P) | Motor Vehicle Laboratory (p. 675)   | M. Frey, M. Bürckert       | 2 | 4  | W/S  |
| 2182642 | E     | Laser in automotive engineering (p. 679)  | J. Schneider               | 2 | 4  | S    |
| 2149669 | E     | Materials and Processes for Body Lightweight Construction in the Automotive Industry (p. 694) | D. Steegmüller, S. Kienzle | 2 | 4  | W    |
| 2147161 | E     | Intellectual Property Rights and Strategies in Industrial Companies (p. 744)                  | F. Zacharias               | 2 | 4  | W/S  |
| 2123364 | E     | Product, Process and Resource Integration in the Automotive Industry (p. 767)                 | S. Mbang                   | 3 | 4  | S    |
| 2149001 | E     | Production Technology and Management in Automotive (p. 774)                                   | V. Stauch, S. Peters       | 2 | 4  | W    |
| 2115817 | E     | Project Workshop: Automotive Engineering (p. 778)   | F. Gauterin                | 3 | 6  | W/S  |

Master Program

Mechanical Engineering (M.Sc.)

Module Handbook, Date: 10/01/2014

| ID      | Cat | Course   | Lecturer                    | h | CP | Term |
|---------|-----|--|-----------------------------|---|----|------|
| 2113072 | E   | Development of Oil-Hydraulic Power-train Systems (p. 780)                              | G. Geerling, I. Ays         | 2 | 4  | W    |
| 2145182 | E   | Project management in Global Product Engineering Structures (p. 782)                   | P. Gutzmer                  | 2 | 4  | W    |
| 2162256 | E   | Computational Vehicle Dynamics (p. 790)  | C. Proppe                   | 2 | 4  | S    |
| 2146193 | E   | Strategic Product Planing (p. 825)   | A. Siebe                    | 2 | 4  | S    |
| 2146192 | E   | Sustainable Product Engineering (p. 834)   | K. Ziegahn                  | 2 | 4  | S    |
| 2138336 | E   | Behaviour Generation for Vehicles (p. 862)   | C. Stiller, T. Dang         | 2 | 4  | S    |
| 2149655 | E   | Gear Cutting Technology (p. 867)   | M. Klaiber                  | 2 | 4  | W    |
| 2174574 | E   | Materials for Lightweight Construction (p. 877)  | K. Weidenmann               | 2 | 4  | S    |
| 2153425 | E   | Industrial aerodynamics (p. 646)   | T. Breitling                | 2 | 4  | W    |
| 2133103 | E   | Fundamentals of Combustion Engines I (p. 629)  | H. Kubach, T. Koch          | 3 | 4  | W    |
| 2134131 | E   | Fundamentals of Combustion Engines II (p. 630)   | H. Kubach, T. Koch          | 3 | 4  | S    |
| 2150904 | E   | Automated Manufacturing Systems (p. 514)   | J. Fleischer                | 6 | 8  | S    |
| 2113102 | E   | Introduction to Automotive Lightweight Technology (p. 584)                             | F. Henning                  | 2 | 4  | W    |
| 2114053 | E   | Composites for Lightweight Design (p. 588)   | F. Henning                  | 2 | 4  | S    |
| 2157445 | E   | Computational methods for the heat protection of a full vehicle (p. 845)               | H. Reister                  | 2 | 4  | W    |
| 23321   | E   | Hybrid and Electric Vehicles (p. 641)  | M. Doppelbauer, M. Schiefer | 3 | 4  | W    |
| 5012053 | E   | (p. 808)   | T. Meyer                    | 2 | 4  | W/S  |
| 2150601 | E   | Integrative Strategies in Production and Development of High Performance Cars (p. 656) | K. Schlichtenmayer          | 2 | 4  | S    |
| 2185264 | E   | Simulation in product development process (p. 812)                                     | T. Böhlke                   | 2 | 4  | W    |
| 2146208 | E   | Dimensioning and Optimization of Power Train System (p. 513)                           | E. Kirchner                 | 2 | 4  | S    |

**Conditions:** The courses [2113805] and [2113809] can not be combined within this major field

The courses [2114835] and [2114855] can not be combined within this major field

The courses [2113806] and [2114856] can not be combined within this major field

The courses [2114825] and [2114857] can not be combined within this major field

**Recommendations:**

**Learning Outcomes:** The student

- knows the most important components of a vehicle,
- knows and understands the functioning and the interaction of the individual components,
- knows the basics of dimensioning the components,
- knows and understands the procedures in automobile development,
- knows and understands the technical specifications at the development procedures,
- is aware of notable boundaries like legislation,
- is ready to analyze and judge vehicle concepts and to participate competently in the development of vehicles.

**Remarks:**

**SP 15: Fundamentals of Energy Technology**

| ID      | Cat    | Course   | Lecturer                      | h | CP | Term |
|---------|--------|--|-------------------------------|---|----|------|
| 2130927 | KP     | Fundamentals of Energy Technology (p. 615)                               | A. Badea                      | 5 | 8  | S    |
| 2130921 | K      | Energy Systems II: Nuclear Energy and Reactor Technology (p. 571)        | A. Badea                      | 3 | 4  | S    |
| 2166538 | K      | Fundamentals of combustion II (p. 628)                                   | U. Maas                       | 2 | 4  | S    |
| 2157432 | K      | Hydraulic Fluid Machinery I (Basics) (p. 643)                            | M. Gabi                       | 4 | 8  | W    |
| 2169453 | K      | Thermal Turbomachines I (p. 848)   | H. Bauer                      | 3 | 6  | W    |
| 2117500 | E      | Energy efficient intralogistic systems (p. 568)                          | F. Schönung                   | 2 | 4  | W    |
| 2171486 | E (P)  | Integrated measurement systems for fluid mechanics applications (p. 657) | H. Bauer, Mitarbeiter         | 5 | 4  | W/S  |
| 2171487 | E (P)  | Laboratory Exercise in Energy Technology (p. 681)                        | H. Bauer, U. Maas, H. Wirbser | 4 | 4  | W/S  |
| 23737   | E      | Photovoltaics (p. 745)   | M. Powalla                    | 3 | 6  | S    |
| 2189910 | E      | Flows and Heat Transfer in Energy Technology (p. 828)                    | X. Cheng                      | 2 | 4  | W    |
| 2169472 | E      | Thermal Solar Energy (p. 846)  | R. Stieglitz                  | 2 | 4  | W    |
| 2133108 | EM     | Fuels and Lubricants for Combustion Engines (p. 521)                     | B. Kehrwald                   | 2 | 4  | W    |
| 2169459 | EM (P) | CFD-Lab using Open Foam (p. 539)   | R. Koch                       | 3 | 4  | W    |
| 2158105 | EM     | Hydraulic Fluid Machinery II (p. 644)                                    | S. Caglar, M. Gabi            | 2 | 4  | S    |
| 2134134 | EM     | Analysis tools for combustion diagnostics (p. 712)                       | U. Wagner                     | 2 | 4  | S    |
| 2157441 | EM     | Computational Methods in Fluid Mechanics (p. 739)                        | F. Magagnato                  | 2 | 4  | W    |
| 2169458 | EM     | Numerical simulation of reacting two phase flows (p. 741)                | R. Koch                       | 2 | 4  | W    |
| 2146192 | EM     | Sustainable Product Engineering (p. 834)                                 | K. Ziegahn                    | 2 | 4  | S    |
| 2158107 | EM     | Technical Acoustics (p. 836)   | M. Gabi                       | 2 | 4  | S    |
| 2133103 | EM     | Fundamentals of Combustion Engines I (p. 629)                            | H. Kubach, T. Koch            | 3 | 4  | W    |
| 2129901 | E      | Energy Systems I: Renewable Energy (p. 569)                              | R. Dagan                      | 3 | 6  | W    |
| 2157444 | EM (P) | Introduction to numerical fluid dynamics (p. 560)                        | B. Pritz                      | 2 | 4  | W    |
| 2189906 | E      | (p. 746)   | R. Dagan, Dr. Volker Metz     | 1 | 2  | W    |
| 2154200 | E      | (p. 603)   | F. Magagnato                  | 2 | 4  | S    |
| 2158206 | E      | (p. 725)   | F. Schmidt                    | 2 | 4  | S    |
| 2157381 | E      | Windpower (p. 883)   | N. Lewald                     | 2 | 3  | W    |

**Conditions:** None.

**Recommendations:** Recommended Course:

- 22512 Heat- and Mass transfer

**Learning Outcomes:** After completion of SP 15 students are able:

- to describe the elements of an energy system and their complex interactions,
- to list different conventional energy sources and assess their static range,
- to name the fluctuating supply of renewable energies such as wind, solar radiation, ocean currents and tides etc. and describe its effects on the energy system,
- to assess the effects of external and internal economic, ecological and technical boundary conditions of energy systems and to derive approaches for an optimal mix of different energy technologies,
- to explain the operational principle of well-established power plants as well as of power plants based on renewable energies.

**Remarks:**

**SP 16: Industrial Engineering**

| ID      | Cat | Course  | Lecturer        | h | CP | Term |
|---------|-----|---|-----------------|---|----|------|
| 2109035 | KP  | Human Factors Engineering I (p. 496)                                  | B. Deml         | 2 | 4  | W    |
| 2109028 | KP  | Production Management I (p. 768)                                      | P. Stock        | 2 | 4  | W    |
| 2110037 | E   | Occupational Safety and Environmental Protection (in German) (p. 648) | R. von Kiparski | 2 | 4  | S    |
| 2109032 | E   | Simulation Aided Management (p. 815)                                  | P. Stock        | 2 | 4  | W    |

**Conditions:****Recommendations:**

**Learning Outcomes:** After completion this module, the students are able to apply typical methods and tools for the evaluation, organisation and design of complex industrial processes in order to solve technical, organisational, ergonomic and economic problems.

The students acquire in the compulsory core subjects profound knowledge about the scientific theories, principles and methods of Human Factors Engineering, Work Analysis, structural and process organisation as well as Production Planning and Control. The students deepen in the elective courses their knowledge by solving case studies of Human Factors Engineering and Production Management. Afterwards the students are able to analyse, evaluate and solve problems of the field of Industrial Engineering.

**Remarks:**

**SP 18: Information Technology**

| ID      | Cat   | Course  | Lecturer  | h | CP | Term |
|---------|-------|---|---|---|----|------|
| 2106004 | K     | Computational Intelligence I (p. 541)   | G. Bretthauer, R. Mikut                         | 2 | 4  | S    |
| 2105015 | K     | Computational Intelligence II (p. 542)  | G. Bretthauer, R. Mikut                         | 2 | 4  | W    |
| 2137309 | K     | Digital Control (p. 546)  | M. Knoop  | 2 | 4  | W    |
| 2137308 | K     | Machine Vision (p. 686)   | C. Stiller, M. Lauer                            | 4 | 8  | W    |
| 2138326 | K     | Measurement II (p. 711)   | C. Stiller                                      | 2 | 4  | S    |
| 2106002 | K     | Computer Engineering (p. 839)   | G. Bretthauer                                   | 3 | 4  | S    |
| 2105012 | E     | Adaptive Control Systems (p. 478)   | G. Bretthauer                                   | 2 | 4  | W    |
| 2118089 | E     | Application of technical logistics in sorting- and distribution technology (p. 494) | J. Föllner                                      | 2 | 4  | S    |
| 2114092 | E     | BUS-Controls (p. 533)   | M. Geimer                                       | 2 | 4  | S    |
| 2106020 | E     | Computational Intelligence III (p. 543)   | R. Mikut  | 2 | 4  | S    |
| 2138340 | E     | Automotive Vision (p. 587)  | C. Stiller, M. Lauer                            | 2 | 4  | S    |
| 2118094 | E     | Information Systems in Logistics and Supply Chain Management (p. 651)               | C. Kilger                                       | 2 | 4  | S    |
| 2105022 | E     | Information Processing in Mechatronic Systems (p. 652)                              | M. Kaufmann                                     | 2 | 4  | W    |
| 2118183 | E     | IT-Fundamentals of Logistics (p. 662)   | F. Thomas                                       | 2 | 4  | S    |
| 2105014 | E (P) | Laboratory mechatronics (p. 707)  | A. Albers, G. Bretthauer, C. Proppe, C. Stiller | 3 | 4  | W    |
| 2134137 | E     | Engine measurement techniques (p. 728)  | S. Bernhardt                                    | 2 | 4  | S    |
| 2137306 | E (P) | Lab Computer-aided methods for measurement and control (p. 762)                     | C. Stiller, P. Lenz                             | 3 | 4  | W    |
| 2150683 | E     | Control Technology (p. 822)   | C. Gönzheimer                                   | 2 | 4  | S    |
| 2138336 | E     | Behaviour Generation for Vehicles (p. 862)  | C. Stiller, T. Dang                             | 2 | 4  | S    |
| 24102   | E     | Information Processing in Sensor Networks (p. 653)                                  | U. Hanebeck, F. Beutler                         | 3 | 4  | W    |

**Conditions:****Recommendations:**

**Learning Outcomes:** Students are able to

- explain fundamentals of information technology for given problems in mechanical engineering and mechatronics.
- explain major methods for acquisition, processing and exploitation of information in technical systems.
- outline and to explain alternative methods to determine and to represent measurement uncertainties and their propagation in technical systems.
- explain information filters and fusion methods and understand their application to given problems.

**Remarks:**

**SP 19: Information Technology of Logistic Systems**

| ID      | Cat | Course  | Lecturer              | h | CP | Term |
|---------|-----|---|-----------------------|---|----|------|
| 2118094 | K   | Information Systems in Logistics and Supply Chain Management (p. 651)               | C. Kilger             | 2 | 4  | S    |
| 2118183 | K   | IT-Fundamentals of Logistics (p. 662)   | F. Thomas             | 2 | 4  | S    |
| 2118078 | K   | Logistics - organisation, design and control of logistic systems (p. 682)           | K. Furmans            | 4 | 6  | S    |
| 2118089 | E   | Application of technical logistics in sorting- and distribution technology (p. 494) | J. Föllner            | 2 | 4  | S    |
| 2138340 | E   | Automotive Vision (p. 587)  | C. Stiller, M. Lauer  | 2 | 4  | S    |
| 2118097 | E   | Warehousing and distribution systems (p. 677)                                       | M. Schwab, J. Weiblen | 2 | 4  | S    |
| 2117056 | E   | Airport logistics (p. 684)  | A. Richter            | 2 | 4  | W    |
| 2117062 | E   | Supply chain management (p. 833)  | K. Alicke             | 4 | 6  | W    |

**Conditions:** none

**Recommendations:** Recommended compulsory optional subjects:

- Basics of statistic and probability theory
- Simulation of production systems and processes
- Stochastics in Mechanical Engineering
- Integrated Information Systems for engineers
- Modelling and Simulation

**Learning Outcomes:** Students are able to:

- Describe and explain soft- and hardware for logistical systems including Supply-Chains,
- Choose control mechanisms and communication systems and describe their basic functions,
- Compare strength and weaknesses of different approaches and evaluate the fundamental suitability.

**Remarks:** none

**SP 20: Integrated Product Development**

| ID      | Cat | Course   | Lecturer          | h | CP | Term |
|---------|-----|--|-------------------|---|----|------|
| 2145156 | KP  | Integrated Product Development (p. 658)                                      | A. Albers         | 8 | 16 | W    |
| 2145150 | E   | Powertrain Systems Technology B: Stationary Machinery (p. 492)               | A. Albers, S. Ott | 2 | 4  | W    |
| 2145184 | E   | Leadership and Product Development (p. 680)                                  | A. Ploch          | 2 | 4  | W    |
| 2147161 | E   | Intellectual Property Rights and Strategies in Industrial Companies (p. 744) | F. Zacharias      | 2 | 4  | W/S  |
| 2145182 | E   | Project management in Global Product Engineering Structures (p. 782)         | P. Gutzmer        | 2 | 4  | W    |
| 2149667 | E   | Quality Management (p. 785)  | G. Lanza          | 2 | 4  | W    |
| 2146193 | E   | Strategic Product Planning (p. 825)  | A. Siebe          | 2 | 4  | S    |
| 2146192 | E   | Sustainable Product Engineering (p. 834)                                     | K. Ziegahn        | 2 | 4  | S    |

**Conditions:** The participation in "Integrated Product Development" requires the concurrent participation in lectures (2145156), tutorials (2145157) and project work (2145300).

Due to organizational reasons, the number of participants is limited. Thus a selection has to be made. For registration to the selection process a standard form has to be used, that can be downloaded from IPEK homepage from april to july. The selection itself is made by Prof. Albers in personal interviews.

**Recommendations:** Recommended Courses:

2147175 CAE-Workshop

**Learning Outcomes:** By working practically in experience-based learning arrangements with industrial development tasks, graduates are able to succeed in new and unknown situations when developing innovative products by using methodological and systematic approaches. They can apply and adapt strategies of development and innovation management, technical system analysis and team leadership to the situation. As a result, they are able to foster the development of innovative products in industrial development teams in prominent positions, taking into account social, economic and ethical aspects.

**Remarks:**

**SP 21: Nuclear Energy**

| ID      | Cat    | Course  | Lecturer                  | h | CP | Term |
|---------|--------|---|---------------------------|---|----|------|
| 2130926 | K      | Energy systems II: Reactor Technology (p. 570)  | A. Badea                  | 3 | 6  | S    |
| 2170460 | K      | Nuclear Power Plant Technology (p. 666)   | T. Schulenberg, K. Litfin | 2 | 4  | S    |
| 2189907 | K      | Heat Transfer in Nuclear Reactors (p. 873)  | X. Cheng                  | 2 | 4  | S    |
| 2189903 | K      | Introduction to Nuclear Energy (p. 552)   | X. Cheng                  | 3 | 6  | W    |
| 2189910 | EM     | Flows and Heat Transfer in Energy Technology (p. 828)   | X. Cheng                  | 2 | 4  | W    |
| 23271   | EM     | Radiation Protection I: Ionising Radiation (p. 824)   | B. Breustedt, M. Urban    | 2 | 4  | W    |
| 2130973 | EM     | Innovative Nuclear Systems (p. 655)   | X. Cheng                  | 2 | 4  | S    |
| 2189465 | EM     | Reactor Safety I: Fundamentals (p. 788)   | V. Sánchez-Espinoza       | 2 | 4  | S    |
| 2169470 | EM     | Two-Phase Flow and Heat Transfer (p. 885)   | T. Schulenberg, M. Wörner | 2 | 4  | W    |
| 2130910 | EM     | CFD for Power Engineering (p. 538)  | I. Otic                   | 2 | 4  | S    |
| 2129901 | EM     | Energy Systems I: Renewable Energy (p. 569)   | R. Dagan                  | 3 | 6  | W    |
| 2194650 | EM     | Materials under high thermal or neutron loads (p. 844)  | A. Möslang, M. Rieth      | 2 | 4  | S    |
| 19435   | EM     | Decommissioning of Nuclear Facilities I (p. 800)  | S. Gentes                 | 2 | 4  | W    |
| 2181745 | EM     | Design of highly stresses components (p. 511)   | J. Aktaa                  | 2 | 4  | W    |
| 2190465 | EM     | Fundamentals of reactor safety for the operation and dismantling of nuclear power plants (p. 624) | V. Sánchez-Espinoza       | 2 | 4  | W    |
| 2189904 | EM     | Ten lectures on turbulence (p. 843)   | I. Otic                   | 2 | 4  | W    |
| 2190490 | EM     | Introduction to Neutron Cross Section Theory and Nuclear Data Generation (p. 661)                 | R. Dagan                  | 2 | 4  | S    |
| 2190913 | EM (P) | Measurement technique for fluid mechanics (p. 710)  | X. Cheng                  | 2 | 3  | S    |
| 5010    | EM     | Nuclear Fuel Cycle and Radiochemistry (p. 787)  | H. Geckeis                | 2 | 4  | W    |
| 2190411 | E      | Selected Problems of Applied Reactor Physics and Exercises (p. 509)                               | R. Dagan                  | 2 | 4  | S    |
| 2189901 | EM     | Tutorial for Heat Transfer in Nuclear Reactors (p. 856)   | X. Cheng                  | 1 | 1  | W/S  |
| 2154200 | E      | (p. 603)  | F. Magagnato              | 2 | 4  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** Students acquire the basic and advanced knowledge of nuclear technology and are able to apply the assimilated knowledge in practice and to analyze and solve by themselves important questions in the nuclear energy field.

The courses of this module are built on three levels. With the overview lecture "Introduction into Nuclear Power", the students acquire broad basic knowledge of nuclear energy and are able to further study in-depth courses in various disciplines, namely thermal-hydraulics, reactor physics and materials science. As a result, students will understand the important processes of nuclear technology, such as control, heat transport and material behavior in a nuclear reactor. The properties of various nuclear systems, especially nuclear power plants, are available for study on the third level of the lectures. The students will possess then the ability to compare and analyze different nuclear systems.

**Remarks:**

**SP 22: Cognitive Technical Systems**

| ID      | Cat   | Course  | Lecturer  | h | CP | Term |
|---------|-------|---|---|---|----|------|
| 2106004 | K     | Computational Intelligence I (p. 541)                                 | G. Bretthauer, R. Mikut                         | 2 | 4  | S    |
| 2138340 | K     | Automotive Vision (p. 587)  | C. Stiller, M. Lauer                            | 2 | 4  | S    |
| 2138336 | K     | Behaviour Generation for Vehicles (p. 862)                            | C. Stiller, T. Dang                             | 2 | 4  | S    |
| 2105015 | E     | Computational Intelligence II (p. 542)                                | G. Bretthauer, R. Mikut                         | 2 | 4  | W    |
| 2106020 | E     | Computational Intelligence III (p. 543)                               | R. Mikut  | 2 | 4  | S    |
| 2137309 | E     | Digital Control (p. 546)  | M. Knoop  | 2 | 4  | W    |
| 2118094 | E     | Information Systems in Logistics and Supply Chain Management (p. 651) | C. Kilger                                       | 2 | 4  | S    |
| 2138341 | E     | Cognitive Automobiles - Laboratory (p. 668)                           | C. Stiller, M. Lauer, B. Kitt                   | 2 | 4  | S    |
| 2137308 | E     | Machine Vision (p. 686)   | C. Stiller, M. Lauer                            | 4 | 8  | W    |
| 2105014 | E (P) | Laboratory mechatronics (p. 707)                                      | A. Albers, G. Bretthauer, C. Proppe, C. Stiller | 3 | 4  | W    |
| 2138326 | E     | Measurement II (p. 711)   | C. Stiller                                      | 2 | 4  | S    |
| 2137306 | E (P) | Lab Computer-aided methods for measurement and control (p. 762)       | C. Stiller, P. Lenz                             | 3 | 4  | W    |
| 2162256 | E     | Computational Vehicle Dynamics (p. 790)                               | C. Proppe                                       | 2 | 4  | S    |
| 24152   | E     | Robotics I – Introduction to robotics (p. 796)                        | R. Dillmann, S. Schmidt-Rohr                    | 2 | 3  | W    |
| 24102   | E     | Information Processing in Sensor Networks (p. 653)                    | U. Hanebeck, F. Beutler                         | 3 | 4  | W    |
| 24572   | E     | Cognitive Systems (p. 669)  | R. Dillmann, A. Waibel                          | 4 | 6  | S    |
| 24613   | E     | Localization of Mobile Agents (p. 685)                                | U. Hanebeck, M. Baum                            | 3 | 4  | S    |
| 24635   | E     | Robotik III - Sensors in Robotics (p. 798)                            | R. Dillmann, Meißner, Gonzalez, Aguirre         | 2 | 3  | S    |
| 23064   | E     | Analysis and Design of Multisensor Systems (p. 485)                   | G. Trommer, G. Trommer                          | 2 | 3  | S    |

**Conditions:****Recommendations:** Students are able to

- explain fundamental components and processing steps of cognitive technical systems
- explain the interplay of individual components and the flow of information between them
- outline the major properties of cognitive functions at examples in emerging applications like vehicular technology or robotics
- determine the level of system function and safety for cognitive technical systems

**Learning Outcomes:****Remarks:**

**SP 23: Power Plant Technology**

| ID      | Cat   | Course   | Lecturer                      | h | CP | Term |
|---------|-------|--|-------------------------------|---|----|------|
| 2157432 | K     | Hydraulic Fluid Machinery I (Basics) (p. 643)                                | M. Gabi                       | 4 | 8  | W    |
| 2170460 | K     | Nuclear Power Plant Technology (p. 666)                                      | T. Schulenberg, K. Litfin     | 2 | 4  | S    |
| 2169461 | K     | Coal fired power plants (p. 670)   | P. Fritz, T. Schulenberg      | 2 | 4  | W    |
| 2169453 | K     | Thermal Turbomachines I (p. 848)   | H. Bauer                      | 3 | 6  | W    |
| 2170476 | K     | Thermal Turbomachines II (p. 849)  | H. Bauer                      | 3 | 6  | S    |
| 2170490 | K     | Combined Cycle Power Plants (p. 602)   | T. Schulenberg                | 2 | 4  | S    |
| 2181745 | E     | Design of highly stresses components (p. 511)                                | J. Aktaa                      | 2 | 4  | W    |
| 2169483 | E     | Fusion Technology A (p. 600)   | R. Stieglitz                  | 2 | 4  | W    |
| 2165515 | E     | Fundamentals of Combustion I (p. 627)  | U. Maas                       | 2 | 4  | W    |
| 2158105 | E     | Hydraulic Fluid Machinery II (p. 644)  | S. Caglar, M. Gabi            | 2 | 4  | S    |
| 2110037 | E     | Occupational Safety and Environmental Protection (in German) (p. 648)        | R. von Kiparski               | 2 | 4  | S    |
| 2171486 | E (P) | Integrated measurement systems for fluid mechanics applications (p. 657)     | H. Bauer, Mitarbeiter         | 5 | 4  | W/S  |
| 2169452 | E     | Power and Heat economics (p. 674)  | H. Bauer                      | 2 | 4  | W    |
| 2170463 | E     | Cooling of thermally high loaded gas turbine components (p. 676)             | H. Bauer, A. Schulz           | 2 | 4  | S    |
| 2171487 | E (P) | Laboratory Exercise in Energy Technology (p. 681)                            | H. Bauer, U. Maas, H. Wirbser | 4 | 4  | W/S  |
| 2157441 | E     | Computational Methods in Fluid Mechanics (p. 739)                            | F. Magagnato                  | 2 | 4  | W    |
| 2147161 | E     | Intellectual Property Rights and Strategies in Industrial Companies (p. 744) | F. Zacharias                  | 2 | 4  | W/S  |
| 2145182 | E     | Project management in Global Product Engineering Structures (p. 782)         | P. Gutzmer                    | 2 | 4  | W    |
| 2173585 | E     | Fatigue of Metallic Materials (p. 806)                                       | K. Lang                       | 2 | 4  | W    |
| 2158107 | E     | Technical Acoustics (p. 836)   | M. Gabi                       | 2 | 4  | S    |
| 2169472 | E     | Thermal Solar Energy (p. 846)  | R. Stieglitz                  | 2 | 4  | W    |
| 2169462 | E     | Turbine and compressor Design (p. 854)                                       | H. Bauer, A. Schulz           | 2 | 4  | W    |
| 2170495 | E     | Hydrogen Technologies (p. 874)   | T. Jordan                     | 2 | 4  | S    |
| 2169470 | E     | Two-Phase Flow and Heat Transfer (p. 885)                                    | T. Schulenberg, M. Wörner     | 2 | 4  | W    |
| 2170491 | E (P) | Simulator Exercises Combined Cycle Power Plants (p. 817)                     | T. Schulenberg                | 2 | 2  | S    |
| 2130973 | E     | Innovative Nuclear Systems (p. 655)  | X. Cheng                      | 2 | 4  | S    |
| 2157444 | E (P) | Introduction to numerical fluid dynamics (p. 560)                            | B. Pritz                      | 2 | 4  | W    |
| 2189903 | E     | Introduction to Nuclear Energy (p. 552)                                      | X. Cheng                      | 3 | 6  | W    |
| 2157381 | E     | Windpower (p. 883)   | N. Lewald                     | 2 | 3  | W    |
| 2130974 | E     | Introduction to Nuclear Engineering (p. 553)                                 | X. Cheng                      | 2 | 4  | S    |

**Conditions:** None.

**Recommendations:** Recommended Course:

- 22512 Heat- and Mass transfer

**Learning Outcomes:** After completion of SP 23 students are able:

- to name the different types of centralized and distributed power plants,
- to explain the operational principle of well-established power plants as well as of power plants based on renewable energies.
- to predict the electric, respectively thermal efficiency of power plants,
- to assess the economics of power plants,

- to highlight the environmental impact of conventional power plants and of renewable energies,
- to assess the availability, operational safety and flexibility of different types of power plants,
- to develop advanced power plants based on thermodynamic, fluid mechanical and other basics.

**Remarks:**

**SP 24: Energy Converting Engines**

| ID      | Cat   | Course   | Lecturer              | h | CP | Term |
|---------|-------|--|-----------------------|---|----|------|
| 2157432 | K     | Hydraulic Fluid Machinery I (Basics) (p. 643)                            | M. Gabi               | 4 | 8  | W    |
| 2169453 | K     | Thermal Turbomachines I (p. 848)   | H. Bauer              | 3 | 6  | W    |
| 2133103 | K     | Fundamentals of Combustion Engines I (p. 629)                            | H. Kubach, T. Koch    | 3 | 4  | W    |
| 2158112 | E     | Low Temperature Technology (p. 486)                                      | F. Haug               | 2 | 4  | S    |
| 22509   | E     | Design of combustion chamber in gas turbines (Project) (p. 510)          | N. Zarzalis           | 2 | 4  | S    |
| 2133108 | E     | Fuels and Lubricants for Combustion Engines (p. 521)                     | B. Kehrwald           | 2 | 4  | W    |
| 2114093 | E     | Fluid Technology (p. 598)  | M. Geimer, M. Scherer | 4 | 4  | W    |
| 2134138 | E     | Fundamentals of catalytic exhaust gas aftertreatment (p. 619)            | E. Lox                | 2 | 4  | S    |
| 2165515 | E     | Fundamentals of Combustion I (p. 627)                                    | U. Maas               | 2 | 4  | W    |
| 2166538 | E     | Fundamentals of combustion II (p. 628)                                   | U. Maas               | 2 | 4  | S    |
| 2158105 | E     | Hydraulic Fluid Machinery II (p. 644)                                    | S. Caglar, M. Gabi    | 2 | 4  | S    |
| 2157441 | E     | Computational Methods in Fluid Mechanics (p. 739)                        | F. Magagnato          | 2 | 4  | W    |
| 2158107 | E     | Technical Acoustics (p. 836)   | M. Gabi               | 2 | 4  | S    |
| 2170476 | E     | Thermal Turbomachines II (p. 849)  | H. Bauer              | 3 | 6  | S    |
| 2169462 | E     | Turbine and compressor Design (p. 854)                                   | H. Bauer, A. Schulz   | 2 | 4  | W    |
| 2170478 | E     | Turbo Jet Engines (p. 855)   | H. Bauer, A. Schulz   | 2 | 4  | S    |
| 2134131 | E     | Fundamentals of Combustion Engines II (p. 630)                           | H. Kubach, T. Koch    | 3 | 4  | S    |
| 2113072 | E     | Development of Oil-Hydraulic Powertrain Systems (p. 780)                 | G. Geerling, I. Ays   | 2 | 4  | W    |
| 2157445 | E     | Computational methods for the heat protection of a full vehicle (p. 845) | H. Reister            | 2 | 4  | W    |
| 2157451 | E     | Wind and Hydropower (p. 882)   | M. Gabi, N. Lewald    | 2 | 4  | W    |
| 2157444 | E (P) | Introduction to numerical fluid dynamics (p. 560)                        | B. Pritz              | 2 | 4  | W    |
| 2154200 | E     | (p. 603)   | F. Magagnato          | 2 | 4  | S    |
| 2157381 | E     | Windpower (p. 883)   | N. Lewald             | 2 | 3  | W    |

**Conditions:**

**Recommendations:** Recommended compulsory optional subject

22512 Heat and mass transfer

**Learning Outcomes:** Die Studierenden erwerben in den grundlagenorientierten Kernfächern des Schwerpunktes breite und fundierte Kenntnisse der wissenschaftlichen Theorien, Prinzipien und Methoden der Kraft- und Arbeitsmaschinen, um diese entwerfen, einsetzen und bewerten zu können.

Darauf aufbauend vertiefen die Studierenden in den Ergänzungsfächern ausgewählte Anwendungsfelder, sodass sie im Anschluss in der Lage sind, Probleme aus diesem Anwendungsfeld selbstständig zu analysieren, zu bewerten und hierauf aufbauend Lösungsansätze zu entwickeln.

Die Studierenden können nach Abschluss des Schwerpunkts insbesondere

- Funktion und Einsatz von Kraft- und Arbeitsmaschinen benennen,
- den Stand der Technik und daraus resultierende Anwendungsfelder der Kraft- und Arbeitsmaschinen beschreiben und am Beispiel anzuwenden,
- grundlegende Theorien, Methoden und Eigenschaften für die verschiedenen Anwendungsfelder der Kraft- und Arbeitsmaschinen benennen und diese einsetzen und bewerten.

**Remarks:**

**SP 25: Lightweight Construction**

| ID      | Cat   | Course  | Lecturer                          | h | CP | Term |
|---------|-------|---|-----------------------------------|---|----|------|
| 2113102 | KP    | Introduction to Automotive Lightweight Technology (p. 584)                                    | F. Henning                        | 2 | 4  | W    |
| 2114053 | KP    | Composites for Lightweight Design (p. 588)  | F. Henning                        | 2 | 4  | S    |
| 2146190 | K     | Lightweight Engineering Design (p. 672)   | A. Albers, N. Burkardt            | 2 | 4  | S    |
| 2174574 | K     | Materials for Lightweight Construction (p. 877)   | K. Weidenmann                     | 2 | 4  | S    |
| 2114101 | K     | Methodical Design of Composite Structures (p. 714)  | O. Helms                          | 2 | 4  | S    |
| 2147175 | E (P) | CAE-Workshop (p. 536)   | A. Albers, Assistenten            | 3 | 4  | W/S  |
| 2161229 | E     | Designing with numerical methods in product development (p. 547)                              | E. Schnack                        | 2 | 4  | W    |
| 2162255 | E     | Designing with composites (p. 548)  | E. Schnack                        | 2 | 4  | S    |
| 2162282 | E     | Introduction to the Finite Element Method (p. 551)  | T. Böhlke                         | 4 | 5  | S    |
| 2178734 | E     | Introduction to the Mechanics of Composite Materials (p. 555)                                 | Y. Yang                           | 2 | 4  | S    |
| 2117500 | E     | Energy efficient intralogistic systems (p. 568)   | F. Schönung                       | 2 | 4  | W    |
| 2182731 | E (P) | Finite Element Workshop (p. 594)  | C. Mattheck, D. Weygand           | 2 | 4  | S    |
| 2174575 | E     | Foundry Technology (p. 609)   | C. Wilhelm                        | 2 | 4  | S    |
| 2161252 | E     | Advanced Methods in Strength of Materials (p. 640)  | T. Böhlke                         | 4 | 4  | W    |
| 2174571 | E     | Design with Plastics (p. 671)   | M. Liedel                         | 2 | 4  | S    |
| 2182642 | E     | Laser in automotive engineering (p. 679)  | J. Schneider                      | 2 | 4  | S    |
| 2149669 | E     | Materials and Processes for Body Lightweight Construction in the Automotive Industry (p. 694) | D. Steegmüller, S. Kienzle        | 2 | 4  | W    |
| 2173590 | E     | Polymer Engineering I (p. 752)  | P. Elsner                         | 2 | 4  | W    |
| 2173565 | E     | Welding Technology I (p. 802)   | B. Spies                          | 1 | 2  | W    |
| 2174570 | E     | Welding Technology II (p. 804)  | B. Spies                          | 1 | 2  | S    |
| 2181715 | E     | Failure of Structural Materials: Fatigue and Creep (p. 863)                                   | O. Kraft, P. Gumbusch, P. Gruber  | 2 | 4  | W    |
| 2181711 | E     | Failure of structural materials: deformation and fracture (p. 865)                            | P. Gumbusch, O. Kraft, D. Weygand | 2 | 4  | W    |
| 2150904 | E     | Automated Manufacturing Systems (p. 514)  | J. Fleischer                      | 6 | 8  | S    |
| 2161983 | E     | Mechanics of laminated composites (p. 704)  | E. Schnack                        | 2 | 4  | W    |

**Conditions:****Recommendations:** Empfohlene Wahlpflichtfächer:

- 2174576 Systematische Werkstoffauswahl

**Learning Outcomes:** Leichtbau ist die Umsetzung eine Entwicklungsstrategie, die darauf ausgerichtet ist, die geforderte Funktion unter vorgegebenen Randbedingungen durch ein System minimaler Masse über die Produktlebenszeit zu realisieren.

Leichtbaubestrebungen lassen sich daher immer als Optimierungsproblem ausdrücken, dass durch geeignete Maßnahmen möglichst effizient gelöst werden muss. Bezogen auf die Fahrzeugindustrie bedeutet das, die Fahrzeuggesamtmasse zu reduzieren ohne dabei wichtige Eigenschaften wie die Karosseriesteifigkeiten und Crasheigenschaften negativ zu beeinflussen.

Um das Optimierungsproblem Leichtbau technisch wie wirtschaftlich möglichst effizient zu lösen, bedarf es einem interdisziplinären Ansatz. Das heißt, es bedarf spezifischem Know-how in vielen Bereichen der Werkstoff- und Ingenieurwissenschaften, sowie bereichsübergreifendem Denken.

Die Nutzung des maximalen Leichtbaupotentials geht daher einher mit der gezielten Werkstoffentwicklung, der Entwicklung und Anpassung geeigneter Herstellungs- und Nachbearbeitungsverfahren, sowie der Entwicklung von Berechnungstools und Auslegungsmethoden für innovative Leichtbaukonstruktionen.

Die Studierenden erwerben Fähigkeiten die Grundlagen des Leichtbaus zu benennen und auf Problemstellungen in verschiedenen Bereichen des Maschinenbaus, insbesondere der Werkstoffe, der Methoden und der Produktion anzuwenden.

Als elementarer Bestandteil des Moduls können die Studierenden die für den Leichtbau relevanten Werkstoffe erläutern und anwenden. Die Studierenden sind in der Lage, die für den Leichtbau wichtigen Werkstoffe zu beschreiben und zu vergleichen sowie die entsprechenden Methoden zur Konstruktion, Auslegung und Dimensionierung unter der Berücksichtigung entsprechender Verarbeitungstechnologien anzuwenden.

Anhand von Vereinfachungen, die auch in der Praxis Anwendung finden, werden die Studierenden in die Lage versetzt, geeignete Werkstoffe auszuwählen, diese mit geeigneten Methoden zu beschreiben und Produkte unter Berücksichtigung des Herstellprozesses zu entwickeln. Hierbei lernen die Studierenden Prozesse zu analysieren und auf Ihre Effizienz hin zu beurteilen.

**Remarks:**

**SP 26: Materials Science and Engineering**

| ID      | Cat   | Course  | Lecturer   | h | CP | Term |
|---------|-------|---|--|---|----|------|
| 2173553 | K     | Materials Science and Engineering III (p. 878)  | M. Heilmaier                                     | 5 | 8  | W    |
| 2193002 | K     | Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises) (p. 850) | H. Seifert, D. Cupid                             | 2 | 4  | W    |
| 2193003 | K     | Solid State Reactions and Kinetics of Phase Transformations (with exercises) (p. 593)           | P. Franke, K. Krüger                             | 2 | 4  | W    |
| 2174579 | E     | Technology of steel components (p. 842)   | V. Schulze                                       | 2 | 4  | S    |
| 2125757 | E     | Introduction to Ceramics (p. 664)   | M. Hoffmann                                      | 4 | 6  | W    |
| 2193010 | E     | Grundlagen der Herstellungsverfahren der Keramik und Pulvermetallurgie (p. 618)                 | R. Oberacker                                     | 2 | 4  | W    |
| 2194643 | E     | Constitution and Properties of Wear resistant materials (p. 501)                                | S. Ulrich  | 2 | 4  | S    |
| 2174586 | E     | Material Analysis (p. 876)  | J. Gibmeier                                      | 2 | 4  | S    |
| 2175590 | E (P) | Metallographic Lab Class (p. 578)   | K. von Klinski-Wetzel                            | 3 | 4  | W/S  |
| 2174575 | E     | Foundry Technology (p. 609)   | C. Wilhelm                                       | 2 | 4  | S    |
| 2173565 | E     | Welding Technology I (p. 802)   | B. Spies   | 1 | 2  | W    |
| 2174570 | E     | Welding Technology II (p. 804)  | B. Spies   | 1 | 2  | S    |
| 2174574 | E     | Materials for Lightweight Construction (p. 877)   | K. Weidenmann                                    | 2 | 4  | S    |
| 2182642 | E     | Laser in automotive engineering (p. 679)  | J. Schneider                                     | 2 | 4  | S    |
| 2174571 | E     | Design with Plastics (p. 671)   | M. Liedel  | 2 | 4  | S    |
| 2178734 | E     | Introduction to the Mechanics of Composite Materials (p. 555)                                   | Y. Yang  | 2 | 4  | S    |
| 2181740 | E     | Atomistic simulations and molecular dynamics (p. 500)   | P. Gumbsch                                       | 2 | 4  | S    |
| 2173580 | E     | Mechanics and Strengths of Polymers (p. 705)  | B. Graf von Bernstorff                           | 2 | 4  | W    |
| 2183702 | E     | Modelling of Microstructures (p. 719)   | A. August, B. Nestler, D. Weygand                | 3 | 5  | W    |
| 2183703 | E     | Modelling and Simulation (p. 724)   | B. Nestler, P. Gumbsch                           | 3 | 5  | W/S  |
| 2173590 | E     | Polymer Engineering I (p. 752)  | P. Elsner  | 2 | 4  | W    |
| 2183640 | E (P) | Laboratory "Laser Materials Processing" (p. 761)  | J. Schneider, W. Pflöging                        | 3 | 4  | W/S  |
| 2181715 | E     | Failure of Structural Materials: Fatigue and Creep (p. 863)                                     | O. Kraft, P. Gumbsch, P. Gruber                  | 2 | 4  | W    |
| 2181711 | E     | Failure of structural materials: deformation and fracture (p. 865)                              | P. Gumbsch, O. Kraft, D. Weygand                 | 2 | 4  | W    |
| 2173585 | E     | Fatigue of Metallic Materials (p. 806)  | K. Lang  | 2 | 4  | W    |
| 2177601 | EM    | Constitution and Properties of Protective Coatings (p. 502)                                     | S. Ulrich  | 2 | 4  | W    |
| 2181744 | EM    | Size effects in micro and nanostructures materials (p. 614)                                     | P. Gumbsch, D. Weygand, P. Gruber, M. Dienwiebel | 2 | 4  | W    |
| 2126749 | EM    | Advanced powder metals (p. 784)   | R. Oberacker                                     | 2 | 4  | S    |
| 2162280 | EM    | Mathematical Methods in Structural Mechanics (p. 700)   | T. Böhlke  | 3 | 5  | S    |
| 2162344 | EM    | Nonlinear Continuum Mechanics (p. 735)  | T. Böhlke  | 2 | 5  | S    |
| 2126775 | EM    | Structural Ceramics (p. 831)  | M. Hoffmann                                      | 2 | 4  | S    |
| 2182740 | EM    | Materials modelling: dislocation based plasticity (p. 879)                                      | D. Weygand                                       | 2 | 4  | S    |

Master Program

Mechanical Engineering (M.Sc.)

Module Handbook, Date: 10/01/2014

| ID      | Cat | Course                               | Lecturer                                 | h | CP | Term |
|---------|-----|--------------------------------------|--|---|----|------|
| 2181730 | EM  | Evaluation of welded joints (p. 523) | P. Gumbsch, M. Farajian, Farajian, Majid | 2 | 4  | W    |
| 2181750 | EM  | Multi-scale Plasticity (p. 749)      | K. Schulz, C. Greiner                    | 2 | 4  | W    |

**Conditions:****Recommendations:** suggested optional compulsory subject:

- 2174576 Systematic Materials Selection

**Learning Outcomes:** In this key area the students gain competence in selecting metallic materials for mechanical engineering applications by deliberately adjusting their properties via appropriate mechanical and thermal treatments.

Besides the core course in materials science and engineering III, they select a further topic within this key area.

**Remarks:**

**SP 27: Modeling and Simulation in Energy- and Fluid Engineering**

| ID      | Cat   | Course   | Lecturer            | h | CP | Term |
|---------|-------|--|---------------------|---|----|------|
| 2167523 | K     | Modeling of Thermodynamical Processes (p. 723)   | R. Schießl, U. Maas | 3 | 6  | W/S  |
| 2157441 | K     | Computational Methods in Fluid Mechanics (p. 739)                                      | F. Magagnato        | 2 | 4  | W    |
| 2169458 | K     | Numerical simulation of reacting two phase flows (p. 741)                              | R. Koch             | 2 | 4  | W    |
| 2165525 | E     | Mathematical models and methods in combustion theory (p. 701)                          | V. Bykov, U. Maas   | 2 | 4  | W    |
| 2134134 | E     | Analysis tools for combustion diagnostics (p. 712)                                     | U. Wagner           | 2 | 4  | S    |
| 2130934 | E     | Numerical Modeling of Multiphase Flows (p. 740)  | M. Wörner           | 2 | 4  | S    |
| 2154449 | E     | Numerical Simulation of Turbulent Flows (p. 742)                                       | G. Grötzbach        | 3 | 4  | S    |
| 2166543 | E     | Reduction methods for the modeling and the simulation of combustion processes (p. 795) | V. Bykov, U. Maas   | 2 | 4  | S    |
| 2153406 | E     | Flows with chemical reactions (p. 827)   | A. Class            | 2 | 4  | W    |
| 2123375 | E (P) | Virtual Reality Laboratory (p. 871)  | J. Ovtcharova       | 3 | 4  | W/S  |
| 2189904 | E     | Ten lectures on turbulence (p. 843)  | I. Otic             | 2 | 4  | W    |
| 2130910 | E     | CFD for Power Engineering (p. 538)   | I. Otic             | 2 | 4  | S    |
| 2157445 | E     | Computational methods for the heat protection of a full vehicle (p. 845)               | H. Reister          | 2 | 4  | W    |
| 2154200 | E     | (p. 603)   | F. Magagnato        | 2 | 4  | S    |
| 2189910 | E     | Flows and Heat Transfer in Energy Technology (p. 828)                                  | X. Cheng            | 2 | 4  | W    |

**Conditions:** None.

**Recommendations:** Recommended Lecture:

- 2154432 Mathematische Methoden der Strömungslehre

**Learning Outcomes:** After completing SP 27 students can:

- formulate the governing equations for specific systems in energy and fluid mechanics.
- explain the different numerical schemes applied to solve the system of equations.
- use frequently applied simulation tools in a more efficient and successful way.

**Remarks:**

**SP 28: Lifecycle Engineering**

| ID      | Cat    | Course  | Lecturer                     | h | CP | Term |
|---------|--------|---|------------------------------|---|----|------|
| 2121352 | KP     | Virtual Engineering I (p. 869)  | J. Ovtcharova                | 5 | 6  | W    |
| 2122378 | KP     | Virtual Engineering II (p. 870)   | J. Ovtcharova                | 3 | 4  | S    |
| 2123357 | EM (P) | CAD-NX training course (p. 535)   | J. Ovtcharova                | 2 | 2  | W/S  |
| 2147175 | E (P)  | CAE-Workshop (p. 536)   | A. Albers, Assistenten       | 3 | 4  | W/S  |
| 2145180 | E      | Methodic Development of Mechatronic systems (p. 713)                            | A. Albers, W. Burger         | 2 | 4  | W    |
| 2122376 | E      | PLM for Product Development in Mechatronics (p. 750)                            | M. Eigner                    | 2 | 4  | S    |
| 2121350 | E      | Product Lifecycle Management (p. 765)   | J. Ovtcharova                | 4 | 6  | W    |
| 2122387 | E      | Computer Integrated Planning of New Products (p. 792)                           | R. Kläger                    | 2 | 4  | S    |
| 2117061 | E      | Safety Engineering (p. 809)   | H. Kany                      | 2 | 4  | W    |
| 2117062 | E      | Supply chain management (p. 833)  | K. Aliche                    | 4 | 6  | W    |
| 2146192 | E      | Sustainable Product Engineering (p. 834)  | K. Ziegahn                   | 2 | 4  | S    |
| 2123375 | EM (P) | Virtual Reality Laboratory (p. 871)   | J. Ovtcharova                | 3 | 4  | W/S  |
| 2117059 | E      | Mathematical models and methods for Production Systems (p. 702)                 | K. Furmans, J. Stoll         | 4 | 6  | W    |
| 2110046 | E      | Productivity Management in Production Systems (p. 776)                          | S. Stowasser                 | 2 | 4  | S    |
| 2109042 | E      | Introduction to Industrial Production Economics (p. 647)                        | S. Dürrschnabel              | 2 | 4  | W    |
| 2149680 | E      | Project Mikro Manufacturing: Design and Manufacturing of Micro Systems (p. 779) | V. Schulze, P. Hoppen        | 3 | 6  | W    |
| 2123380 | E      | CATIA advanced (p. 537)   | J. Ovtcharova                | 2 | 2  | S    |
| 2122014 | E      | Information Engineering (p. 650)  | J. Ovtcharova, J. Ovtcharova | 2 | 3  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** Student gain a basic understanding of holistic development, validation and production of products, components and systems.

Students are able to appreciate the product and process complexity of today's products and manufacturing facilities. They know exemplary IT-Systems to support the complexity.

Students can describe the necessary information management for the product emergence process.

Students know the fundamental terms or virtual reality and are able to use a CAVE as tool to promote technical or management decisions.

**Remarks:**

**SP 29: Logistics and Material Flow Theory**

| ID      | Cat   | Course  | Lecturer   | h | CP | Term |
|---------|-------|---|--|---|----|------|
| 2117051 | KP    | Material flow in logistic systems (p. 693)                                | K. Furmans   | 4 | 6  | W    |
| 2117059 | K     | Mathematical models and methods for Production Systems (p. 702)           | K. Furmans, J. Stoll   | 4 | 6  | W    |
| 2118078 | K     | Logistics - organisation, design and control of logistic systems (p. 682) | K. Furmans   | 4 | 6  | S    |
| 2137309 | E     | Digital Control (p. 546)  | M. Knoop   | 2 | 4  | W    |
| 2149610 | E     | Global Production and Logistics - Part 1: Global Production (p. 610)      | G. Lanza   | 2 | 4  | W    |
| 2149600 | E     | Global Production and Logistics - Part 2: Global Logistics (p. 612)       | K. Furmans   | 2 | 4  | S    |
| 2118094 | E     | Information Systems in Logistics and Supply Chain Management (p. 651)     | C. Kilger  | 2 | 4  | S    |
| 2118097 | E     | Warehousing and distribution systems (p. 677)                             | M. Schwab, J. Weiblen  | 2 | 4  | S    |
| 2118085 | E     | Automotive Logistics (p. 683)   | K. Furmans   | 2 | 4  | S    |
| 2117056 | E     | Airport logistics (p. 684)  | A. Richter   | 2 | 4  | W    |
| 2110678 | E (P) | Production Techniques Laboratory (p. 772)                                 | K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL | 3 | 4  | S    |
| 2149605 | E     | Simulation of production systems and processes (p. 813)                   | K. Furmans, V. Schulze, P. Stock   | 4 | 5  | W    |
| 2117062 | E     | Supply chain management (p. 833)  | K. Alicke  | 4 | 6  | W    |
| 2117095 | E     | Basics of Technical Logistics (p. 626)                                    | M. Mittwollen, Madzharov   | 4 | 6  | W    |
| 2117096 | E     | Elements of Technical Logistics (p. 565)                                  | M. Mittwollen, Madzharov   | 3 | 4  | W    |
| 2110046 | E     | Productivity Management in Production Systems (p. 776)                    | S. Stowasser   | 2 | 4  | S    |
| 2117097 | E     | Elements of Technical Logistics and Project (p. 566)                      | M. Mittwollen, Madzharov   | 4 | 6  | W    |

**Conditions:** none**Recommendations:** Recommended compulsory optional subjects:

- Basics of statistic and probability theory
- Simulation of production systems and processes
- Stochastics in Mechanical Engineering
- Modelling and Simulation
- Technical Logistics I

**Learning Outcomes:** Students

- acquire comprehensive and well-founded knowledge on the main topics of logistics, an overview of different logistic questions in practice and knows the functionality of material handling systems,
- are able to illustrate logistic systems with adequate accuracy by using simple models,
- are able to realize coherences within logistic systems,
- are able to evaluate logistic systems by using the learnt methods,
- are able to analyze and explain the phenomena of industrial material and value streams
- are able to plan logistic systems and evaluate their performance,
- can use approaches of Supply Chain Management within the operational practice,
- identify, analyse and evaluate risks within logistic systems.

**Remarks:** none

**SP 30: Applied Mechanics**

| ID      | Cat | Course   | Lecturer                 | h | CP | Term |
|---------|-----|--|--------------------------|---|----|------|
| 2161250 | K   | Computational Mechanics I (p. 793)                     | T. Böhlke, T. Langhoff   | 4 | 6  | W    |
| 2161212 | K   | Vibration Theory (p. 840)                              | A. Fidlin                | 3 | 5  | W    |
| 2162296 | K   | Computational Mechanics II (p. 794)                    | T. Böhlke, T. Langhoff   | 4 | 6  | S    |
| 2182732 | E   | Introduction to Theory of Materials (p. 554)           | M. Kamlah                | 2 | 4  | S    |
| 2161216 | E   | Wave propagation (p. 561)                              | W. Seemann               | 2 | 4  | W    |
| 2162247 | E   | Introduction to Nonlinear Vibrations (p. 562)          | A. Fidlin                | 4 | 7  | S    |
| 2181720 | E   | Foundations of nonlinear continuum mechanics (p. 623)  | M. Kamlah                | 2 | 4  | W    |
| 2162280 | E   | Mathematical Methods in Structural Mechanics (p. 700)  | T. Böhlke                | 3 | 5  | S    |
| 2161501 | E   | Process Simulation in Forming Operations (p. 783)      | D. Helm                  | 2 | 4  | W    |
| 2162246 | E   | Computational Dynamics (p. 789)                        | C. Proppe                | 2 | 4  | S    |
| 2162256 | E   | Computational Vehicle Dynamics (p. 790)                | C. Proppe                | 2 | 4  | S    |
| 2181738 | E   | Scientific computing for Engineers (p. 884)            | D. Weygand, P. Gumbsch   | 2 | 4  | W    |
| 2161214 | E   | Vibration of continuous systems (p. 673)               | H. Hetzler               | 2 | 4  | S    |
| 2163113 | E   | Theory of Stability (p. 821)                           | A. Fidlin                | 4 | 6  | W    |
| 2153406 | E   | Flows with chemical reactions (p. 827)                 | A. Class                 | 2 | 4  | W    |
| 2161251 | E   | Microstructure characterization and modelling (p. 718) | T. Böhlke, F. Fritzen    | 2 | 5  | W    |
| 01874   | E   | Numerical Mathematics (p. 737)                         | C. Wieners, Neuß, Rieder | 3 | 6  | S    |
| 2162344 | E   | Nonlinear Continuum Mechanics (p. 735)                 | T. Böhlke                | 2 | 5  | S    |
| 2154200 | E   | (p. 603)   | F. Magagnato             | 2 | 4  | S    |

**Conditions:****Recommendations:** Recommended compulsory elective subjects:

- 2161206 Mathematical Methods in Dynamics
- 2161254 Mathematical Methods in Strength of Materials
- 2162280 Mathematical Methods in Structural Mechanics
- 2154432 Mathematical Methods in Fluid Dynamics

**Learning Outcomes:** After having finished this major field the students can

- list important mathematical concepts that are applied in mechanics
- analyze, evaluate and assess models of mechanics according to their mathematical structure
- apply mathematical algorithms for solving special problems in mechanics
- select a mathematical description of a given problem in mechanics

**Remarks:**

**SP 31: Mechatronics**

| ID      | Cat   | Course   | Lecturer  | h | CP | Term |
|---------|-------|--|---|---|----|------|
| 2105012 | K     | Adaptive Control Systems (p. 478)  | G. Bretthauer                                   | 2 | 4  | W    |
| 2106004 | K     | Computational Intelligence I (p. 541)  | G. Bretthauer, R. Mikut                         | 2 | 4  | S    |
| 2105015 | K     | Computational Intelligence II (p. 542)                                       | G. Bretthauer, R. Mikut                         | 2 | 4  | W    |
| 2106020 | K     | Computational Intelligence III (p. 543)                                      | R. Mikut  | 2 | 4  | S    |
| 2105011 | K     | Introduction into Mechatronics (p. 556)                                      | G. Bretthauer, A. Albers                        | 3 | 6  | W    |
| 2162235 | K     | Introduction into the multi-body dynamics (p. 557)                           | W. Seemann                                      | 3 | 5  | S    |
| 2138340 | K     | Automotive Vision (p. 587)   | C. Stiller, M. Lauer                            | 2 | 4  | S    |
| 2105024 | K     | Modern Control Concepts I (p. 726)   | L. Gröll  | 2 | 4  | W    |
| 2138336 | K     | Behaviour Generation for Vehicles (p. 862)                                   | C. Stiller, T. Dang                             | 2 | 4  | S    |
| 2106005 | E     | Automation Systems (p. 516)  | M. Kaufmann                                     | 2 | 4  | S    |
| 2114092 | E     | BUS-Controls (p. 533)  | M. Geimer                                       | 2 | 4  | S    |
| 2147175 | E (P) | CAE-Workshop (p. 536)  | A. Albers, Assistenten                          | 3 | 4  | W/S  |
| 2137309 | E     | Digital Control (p. 546)   | M. Knoop  | 2 | 4  | W    |
| 2118183 | E     | IT-Fundamentals of Logistics (p. 662)  | F. Thomas                                       | 2 | 4  | S    |
| 2161224 | E     | Machine Dynamics (p. 691)  | C. Proppe                                       | 3 | 5  | S    |
| 2162220 | E     | Machine Dynamics II (p. 692)   | C. Proppe                                       | 2 | 4  | W    |
| 2181710 | E     | Mechanics in Microtechnology (p. 706)  | P. Gruber, C. Greiner                           | 2 | 4  | W    |
| 2105014 | E (P) | Laboratory mechatronics (p. 707)   | A. Albers, G. Bretthauer, C. Proppe, C. Stiller | 3 | 4  | W    |
| 2138326 | E     | Measurement II (p. 711)  | C. Stiller                                      | 2 | 4  | S    |
| 2145180 | E     | Methodic Development of Mechatronic systems (p. 713)                         | A. Albers, W. Burger                            | 2 | 4  | W    |
| 2141865 | E     | Novel actuators and sensors (p. 733)   | M. Kohl, M. Sommer                              | 4 | 6  | W    |
| 2147161 | E     | Intellectual Property Rights and Strategies in Industrial Companies (p. 744) | F. Zacharias                                    | 2 | 4  | W/S  |
| 2145182 | E     | Project management in Global Product Engineering Structures (p. 782)         | P. Gutzmer                                      | 2 | 4  | W    |
| 2161217 | E (P) | Mechatronic Softwaretools (p. 819)   | C. Proppe                                       | 2 | 4  | W    |
| 2146192 | E     | Sustainable Product Engineering (p. 834)                                     | K. Ziegahn                                      | 2 | 4  | S    |
| 2123375 | E (P) | Virtual Reality Laboratory (p. 871)  | J. Ovtcharova                                   | 3 | 4  | W/S  |
| 2150904 | E     | Automated Manufacturing Systems (p. 514)                                     | J. Fleischer                                    | 6 | 8  | S    |
| 24152   | E     | Robotics I – Introduction to robotics (p. 796)                               | R. Dillmann, S. Schmidt-Rohr                    | 2 | 3  | W    |
| 24659   | E     | Human-Machine-Interaction (p. 708)   | M. Beigl, Takashi Miyaki                        | 2 | 3  | S    |
| 23109   | E     | Signals and Systems (p. 810)   | F. Puente, F. Puente León                       | 2 | 3  | W    |
| 23321   | E     | Hybrid and Electric Vehicles (p. 641)  | M. Doppelbauer, M. Schiefer                     | 3 | 4  | W    |
| 2106033 | E     | System Integration in Micro- and Nanotechnology (p. 835)                     | U. Gengenbach                                   | 2 | 4  | S    |
| 24600   | E     | Multilingual Human-Machine Communication (p. 729)                            | T. Schultz, F. Putze                            | 4 | 6  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** The topic mechatronics offers a broad, multidisciplinary body of knowledge. The graduates are qualified to solve essential mechatronic questions. In particular the following disciplines are covered by the major mechatronics: § Mechanics and fluidics

§ Electronics

§ Information processing

§ Automation.

Students of the topic mechatronics know the future-oriented procedures. They are able to individually and creatively solve interdisciplinary questions and learn to effectively combine tools from the individual disciplines.

**Remarks:**

**SP 32: Medical Technology**

| ID            | Cat     | Course   | Lecturer                                | h | CP | Term |
|---------------|---------|--|---|---|----|------|
| 2105011       | KP      | Introduction into Mechatronics (p. 556)  | G. Bretthauer, A. Albers                | 3 | 6  | W    |
| 23269         | K       | Biomedical Measurement Techniques I (p. 527)   | W. Stork, A. Bolz                       | 2 | 4  | W    |
| 2141864       | K       | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I (p. 529)  | A. Guber                                | 2 | 4  | W    |
| 2142883       | K       | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II (p. 530)   | A. Guber                                | 2 | 4  | S    |
| 2142879       | K       | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III (p. 531)  | A. Guber                                | 2 | 4  | S    |
| 2106004       | K       | Computational Intelligence I (p. 541)  | G. Bretthauer, R. Mikut                 | 2 | 4  | S    |
| 2105015       | K       | Computational Intelligence II (p. 542)   | G. Bretthauer, R. Mikut                 | 2 | 4  | W    |
| 2106020       | K       | Computational Intelligence III (p. 543)  | R. Mikut                                | 2 | 4  | S    |
| 2142140       | E       | Bionics for Engineers and Natural Scientists (p. 532)  | H. Hölscher                             | 2 | 4  | S    |
| 2105992       | K       | Principles of Medicine for Engineers (p. 620)  | C. Pylatiuk                             | 2 | 4  | W    |
| 2106008       | E       | Organ support systems (p. 575)   | C. Pylatiuk                             | 2 | 4  | S    |
| 2146190       | E       | Lightweight Engineering Design (p. 672)  | A. Albers, N. Burkardt                  | 2 | 4  | S    |
| 2181710       | E       | Mechanics in Microtechnology (p. 706)  | P. Gruber, C. Greiner                   | 2 | 4  | W    |
| 2147161       | E       | Intellectual Property Rights and Strategies in Industrial Companies (p. 744)   | F. Zacharias                            | 2 | 4  | W/S  |
| 2145182       | E       | Project management in Global Product Engineering Structures (p. 782)   | P. Gutzmer                              | 2 | 4  | W    |
| 2149680       | E       | Project Mikro Manufacturing: Design and Manufacturing of Micro Systems (p. 779)  | V. Schulze, P. Hoppen                   | 3 | 6  | W    |
| 23262         | E       | Medical Imaging Techniques II (p. 525)   | O. Dössel, O. Dössel                    | 2 | 3  | S    |
| 23264         | E       | Bioelectric Signals (p. 526)   | G. Seemann, G. Seemann                  | 2 | 3  | S    |
| 23270         | E       | Biomedical Measurement Techniques II (p. 528)  | W. Stork, A. Bolz                       | 2 | 4  | S    |
| 23289         | E       | Nuklear Medicine and Nuklear Medicine Measurement Technics I (p. 736)  | F. Maul, H. Doerfel                     | 1 | 2  | W    |
| 23261         | E       | Medical Imaging Techniques I (p. 524)  | O. Dössel                               | 2 | 3  | W    |
| 24152         | E       | Robotics I – Introduction to robotics (p. 796)   | R. Dillmann, S. Schmidt-Rohr            | 2 | 3  | W    |
| 24712         | E       | Robotics II - Learning and planning robots (p. 797)  | R. Dillmann                             | 2 | 3  | S    |
| 24635         | E       | Robotik III - Sensors in Robotics (p. 798)   | R. Dillmann, Meißner, Gonzalez, Aguirre | 2 | 3  | S    |
| 23105         | E       | Measurement Technology (p. 709)  | F. Puente                               | 3 | 4  | W    |
| 2106033       | E       | System Integration in Micro- and Nanotechnology (p. 835)   | U. Gengenbach                           | 2 | 4  | S    |
| 24139 / 24678 | E       | Human brain and central nervous system: anatomy, information transfer, signal processing, neurophysiology and therapy (p. 606) | U. Spetzger                             | 2 | 3  | W/S  |
| 2143875       | E/P (P) | Introduction to Microsystem Technology - Practical Course (p. 764)   | A. Last                                 | 2 | 4  | W/S  |

| ID    | Cat | Course                    | Lecturer                     | h | CP | Term |
|-------|-----|---------------------------|------------------------------|---|----|------|
| 24681 | E   | Medical Robotics (p. 799) | J. Raczkowski,<br>Raczkowski | 2 | 3  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** The Medical Engineering qualifies students to solve challenges in the field of complex medical and biomedical systems supporting human-centred diagnostics and therapy. Based on the specific requirements for medical products the following topics are taught within the major Medical Engineering:

- Broad basis of relevant medical and biological knowledge
- Measuring technology and signal processing
- Development and Manufacturing of medical products

Graduates of this major know all relevant methods to design modern medical devices and have the ability to efficiently and creatively develop solutions for leading edge medical applications.

**Remarks:**

**SP 33: Microsystem Technology**

| ID      | Cat   | Course  | Lecturer                               | h | CP | Term |
|---------|-------|---|--|---|----|------|
| 2141861 | KP    | Introduction to Microsystem Technology I (p. 621)                               | A. Guber                               | 2 | 4  | W    |
| 2142874 | K     | Introduction to Microsystem Technology II (p. 622)                              | A. Guber                               | 2 | 4  | S    |
| 2143875 | K (P) | Introduction to Microsystem Technology - Practical Course (p. 764)              | A. Last                                | 2 | 4  | W/S  |
| 2143892 | E     | Selected Topics on Optics and Microoptics for Mechanical Engineers (p. 507)     | T. Mappes                              | 2 | 4  | W/S  |
| 2143882 | E     | Fabrication Processes in Microsystem Technology (p. 590)                        | K. Bade                                | 2 | 4  | W/S  |
| 2181710 | E     | Mechanics in Microtechnology (p. 706)   | P. Gruber, C. Greiner                  | 2 | 4  | W    |
| 2142881 | E     | Microactuators (p. 717)   | M. Kohl                                | 2 | 4  | S    |
| 2143876 | E     | Nanotechnology with Clusterbeams (p. 731)                                       | J. Gspann                              | 2 | 4  | W/S  |
| 2141865 | E     | Novel actuators and sensors (p. 733)  | M. Kohl, M. Sommer                     | 4 | 6  | W    |
| 2147161 | E     | Intellectual Property Rights and Strategies in Industrial Companies (p. 744)    | F. Zacharias                           | 2 | 4  | W/S  |
| 2142861 | E     | Nanotechnology for Engineers and Natural Scientists (p. 730)                    | H. Hölscher, M. Dienwiebel, S. Walheim | 2 | 4  | W    |
| 2149605 | E     | Simulation of production systems and processes (p. 813)                         | K. Furmans, V. Schulze, P. Stock       | 4 | 5  | W    |
| 2142884 | EM    | Microoptics and Lithography (p. 716)  | T. Mappes                              | 2 | 4  | S    |
| 2141864 | E     | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I (p. 529)   | A. Guber                               | 2 | 4  | W    |
| 2142883 | E     | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II (p. 530)  | A. Guber                               | 2 | 4  | S    |
| 2142879 | E     | BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III (p. 531) | A. Guber                               | 2 | 4  | S    |
| 2141007 | E     | Fundamentals of X-ray Optics I (p. 625)   | A. Last                                | 2 | 4  | W    |
| 2141853 | E     | Polymers in MEMS A: Chemistry, Synthesis and Applications (p. 754)              | B. Rapp                                | 2 | 4  | W    |
| 2141854 | E     | Polymers in MEMS B: Physics, Microstructuring and Applications (p. 756)         | M. Worgull                             | 2 | 4  | W    |
| 2142140 | E     | Bionics for Engineers and Natural Scientists (p. 532)                           | H. Hölscher                            | 2 | 4  | S    |
| 2143873 | E     | Actual topics of BioMEMS (p. 484)   | A. Guber, Cattaneo, Giorgio            | 2 | 4  | W/S  |
| 2142855 | E     | (p. 758)  | M. Worgull, B. Rapp                    | 2 | 4  | S    |
| 2142856 | E (P) | (p. 760)  | M. Worgull, B. Rapp                    | 2 | 2  | S    |
| 2141866 | E     | Actuators and sensors in nanotechnology (p. 483)                                | M. Kohl                                | 2 | 4  | W    |
| 2142897 | E     | Microenergy Technologies (p. 715)   | M. Kohl                                | 2 | 4  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** In this key area the students gain competence in construction and production of e. g. mechanical, optical, fluidic and sensory microsystems.

**Remarks:** If you have any questions concerning the module, please contact Prof. Dr. Andreas E. Guber.

**SP 34: Mobile Machines**

| ID      | Cat | Course   | Lecturer              | h | CP | Term |
|---------|-----|--|-----------------------|---|----|------|
| 2114073 | KP  | Mobile Machines (p. 721)   | M. Geimer             | 4 | 8  | S    |
| 2113077 | E   | Drive Train of Mobile Machines (p. 489)                                  | M. Geimer, M. Scherer | 3 | 4  | W    |
| 2113079 | E   | Design and Development of Mobile Machines (p. 512)                       | M. Geimer, J. Siebert | 2 | 4  | W    |
| 2114092 | E   | BUS-Controls (p. 533)  | M. Geimer             | 2 | 4  | S    |
| 2117064 | E   | Application of technical logistics in modern crane systems (p. 493)      | M. Golder             | 2 | 4  | W    |
| 2117500 | E   | Energy efficient intralogistic systems (p. 568)                          | F. Schönung           | 2 | 4  | W    |
| 2114093 | E   | Fluid Technology (p. 598)  | M. Geimer, M. Scherer | 4 | 4  | W    |
| 2113812 | E   | Fundamentals in the Development of Commercial Vehicles I (p. 634)        | J. Zürn               | 1 | 2  | W    |
| 2114844 | E   | Fundamentals in the Development of Commercial Vehicles II (p. 635)       | J. Zürn               | 1 | 2  | S    |
| 2145180 | E   | Methodic Development of Mechatronic systems (p. 713)                     | A. Albers, W. Burger  | 2 | 4  | W    |
| 2113072 | E   | Development of Oil-Hydraulic Powertrain Systems (p. 780)                 | G. Geerling, I. Ays   | 2 | 4  | W    |
| 2145182 | E   | Project management in Global Product Engineering Structures (p. 782)     | P. Gutzmer            | 2 | 4  | W    |
| 2114095 | E   | Simulation of Coupled Systems (p. 811)                                   | M. Geimer             | 4 | 4  | S    |
| 2113080 | E   | Tractors (p. 852)  | M. Kremmer            | 2 | 4  | W    |
| 2138336 | E   | Behaviour Generation for Vehicles (p. 862)                               | C. Stiller, T. Dang   | 2 | 4  | S    |
| 2134131 | E   | Fundamentals of Combustion Engines II (p. 630)                           | H. Kubach, T. Koch    | 3 | 4  | S    |
| 2133103 | E   | Fundamentals of Combustion Engines I (p. 629)                            | H. Kubach, T. Koch    | 3 | 4  | W    |
| 2157445 | EM  | Computational methods for the heat protection of a full vehicle (p. 845) | H. Reister            | 2 | 4  | W    |

**Conditions:**

**Recommendations:** Knowledge of Fluid Power Systems is helpful, otherwise it is recommended to take the course *Fluid Power Systems* [2114093].

**Learning Outcomes:** The student

- knows and understands the basic structure of the machines,
- masters the basic skills to develop the selected machines

**Remarks:**

**SP 35: Modeling and Simulation**

| ID      | Cat    | Course   | Lecturer                          | h | CP | Term |
|---------|--------|--|-----------------------------------|---|----|------|
| 2162282 | K      | Introduction to the Finite Element Method (p. 551)                       | T. Böhlke                         | 4 | 5  | S    |
| 2162235 | K      | Introduction into the multi-body dynamics (p. 557)                       | W. Seemann                        | 3 | 5  | S    |
| 2161252 | K      | Advanced Methods in Strength of Materials (p. 640)                       | T. Böhlke                         | 4 | 4  | W    |
| 2161224 | K      | Machine Dynamics (p. 691)  | C. Proppe                         | 3 | 5  | S    |
| 2161212 | K      | Vibration Theory (p. 840)  | A. Fidlin                         | 3 | 5  | W    |
| 2181740 | E      | Atomistic simulations and molecular dynamics (p. 500)                    | P. Gumbsch                        | 2 | 4  | S    |
| 2123358 | E (P)  | CATIA CAD training course (p. 534)                                       | J. Ovtcharova                     | 2 | 2  | W/S  |
| 2123357 | E (P)  | CAD-NX training course (p. 535)  | J. Ovtcharova                     | 2 | 2  | W/S  |
| 2147175 | E (P)  | CAE-Workshop (p. 536)  | A. Albers, Assistenten            | 3 | 4  | W/S  |
| 2169459 | E (P)  | CFD-Lab using Open Foam (p. 539)   | R. Koch                           | 3 | 4  | W    |
| 2162220 | E      | Machine Dynamics II (p. 692)   | C. Proppe                         | 2 | 4  | W    |
| 2165525 | E      | Mathematical models and methods in combustion theory (p. 701)            | V. Bykov, U. Maas                 | 2 | 4  | W    |
| 2134134 | E      | Analysis tools for combustion diagnostics (p. 712)                       | U. Wagner                         | 2 | 4  | S    |
| 2162256 | E      | Computational Vehicle Dynamics (p. 790)                                  | C. Proppe                         | 2 | 4  | S    |
| 2161250 | E      | Computational Mechanics I (p. 793)                                       | T. Böhlke, T. Langhoff            | 4 | 6  | W    |
| 2162296 | E      | Computational Mechanics II (p. 794)                                      | T. Böhlke, T. Langhoff            | 4 | 6  | S    |
| 2114095 | E      | Simulation of Coupled Systems (p. 811)                                   | M. Geimer                         | 4 | 4  | S    |
| 2138336 | E      | Behaviour Generation for Vehicles (p. 862)                               | C. Stiller, T. Dang               | 2 | 4  | S    |
| 2122378 | E      | Virtual Engineering II (p. 870)  | J. Ovtcharova                     | 3 | 4  | S    |
| 2123375 | E (P)  | Virtual Reality Laboratory (p. 871)                                      | J. Ovtcharova                     | 3 | 4  | W/S  |
| 2182740 | E      | Materials modelling: dislocation based plasticity (p. 879)               | D. Weygand                        | 2 | 4  | S    |
| 2181738 | E      | Scientific computing for Engineers (p. 884)                              | D. Weygand, P. Gumbsch            | 2 | 4  | W    |
| 2117059 | EM     | Mathematical models and methods for Production Systems (p. 702)          | K. Furmans, J. Stoll              | 4 | 6  | W    |
| 2163111 | E      | Dynamics of the Automotive Drive Train (p. 550)                          | A. Fidlin                         | 4 | 5  | W    |
| 2163113 | E      | Theory of Stability (p. 821)   | A. Fidlin                         | 4 | 6  | W    |
| 2162247 | E      | Introduction to Nonlinear Vibrations (p. 562)                            | A. Fidlin                         | 4 | 7  | S    |
| 2161241 | E (P)  | Schwingungstechnisches Praktikum (p. 807)                                | H. Hetzler, A. Fidlin             | 3 | 3  | S    |
| 2134139 | E      | Model based Application Methods (p. 722)                                 | F. Kirschbaum                     | 3 | 4  | S    |
| 2161217 | EM (P) | Mechatronic Softwaretools (p. 819)                                       | C. Proppe                         | 2 | 4  | W    |
| 2183721 | E      | High Performance Computing (p. 638)                                      | B. Nestler, M. Selzer             | 3 | 5  | W    |
| 2154430 | E      | Introduction to modeling of aerospace systems (p. 558)                   | G. Schlöffel                      | 2 | 4  | S    |
| 2154437 | E      | Hydrodynamic Stability: From Order to Chaos (p. 645)                     | A. Class                          | 2 | 4  | S    |
| 2153406 | E      | Flows with chemical reactions (p. 827)                                   | A. Class                          | 2 | 4  | W    |
| 2110032 | E      | Production Planning and Control (p. 770)                                 | A. Rinn                           | 2 | 4  | W    |
| 2181614 | E      | Applied Materials Modelling (p. 488)                                     | P. Gumbsch, B. Nestler, A. August | 4 | 7  | S    |
| 2157445 | E      | Computational methods for the heat protection of a full vehicle (p. 845) | H. Reister                        | 2 | 4  | W    |

| ID      | Cat | Course  | Lecturer              | h | CP | Term |
|---------|-----|---|-----------------------|---|----|------|
| 2130934 | E   | Numerical Modeling of Multiphase Flows (p. 740) | M. Wörner             | 2 | 4  | S    |
| 2162225 | E   | Experimental Dynamics (p. 576)                  | A. Fidlin, H. Hetzler | 3 | 5  | S    |
| 2109032 | E   | Simulation Aided Management (p. 815)            | P. Stock              | 2 | 4  | W    |
| 2154200 | E   | (p. 603)  | F. Magagnato          | 2 | 4  | S    |

**Conditions:****Recommendations:**

**Learning Outcomes:** The module provides modelling competence and continues thus the compulsory subject modelling and simulation of the master studies. To this end, courses, case studies and training periods with relation to simulation were combined. Students of this module will be able to carry out simulation studies in typical application fields of mechanical engineering, to judge critically the models and to interpret the obtained results.

**Remarks:**

**SP 36: Polymer Engineering**

| ID      | Cat | Course   | Lecturer               | h | CP | Term |
|---------|-----|--|------------------------|---|----|------|
| 2173590 | K   | Polymer Engineering I (p. 752)                             | P. Elsner              | 2 | 4  | W    |
| 2174596 | K   | Polymer Engineering II (p. 753)                            | P. Elsner              | 2 | 4  | S    |
| 2113102 | E   | Introduction to Automotive Lightweight Technology (p. 584) | F. Henning             | 2 | 4  | W    |
| 2114053 | E   | Composites for Lightweight Design (p. 588)                 | F. Henning             | 2 | 4  | S    |
| 2174571 | E   | Design with Plastics (p. 671)                              | M. Liedel              | 2 | 4  | S    |
| 2173580 | E   | Mechanics and Strengths of Polymers (p. 705)               | B. Graf von Bernstorff | 2 | 4  | W    |

**Conditions:**

**Recommendations:** suggested optional compulsory subject:

- 2174576 Systematic Materials Selection

**Learning Outcomes:** The students...

- are able to choose polymers for applications in mechanical engineering in target-oriented way and are able to justify their selection.
- are able to describe and compare production processes for polymers and PMCs exemplarily.
- are able to describe the mechanical behaviour of polymers and PMC based on scientific theories, principles and methods.
- are able to solve tasks in the field of polymer engineering and proceed adequate to the situation.
- are able to integrate intra-modular knowledge at the solution of given problems.
- have the ability to develop polymer parts in a constructive way under consideration of technical and economic conditions.

**Remarks:** Emphasis module in the master's program only.

**SP 37: Production Management**

| ID      | Cat   | Course   | Lecturer   | h | CP | Term |
|---------|-------|--|--|---|----|------|
| 2109028 | KP    | Production Management I (p. 768)                                     | P. Stock   | 2 | 4  | W    |
| 2110028 | KP    | Production Management II (p. 769)                                    | P. Stock   | 2 | 4  | S    |
| 2109042 | E     | Introduction to Industrial Production Economics (p. 647)             | S. Dürschnabel   | 2 | 4  | W    |
| 2150660 | E     | Integrated production planning (p. 659)                              | G. Lanza   | 6 | 8  | S    |
| 2110017 | E     | Leadership and Conflict Management (in German) (p. 689)              | H. Hatzl   | 2 | 4  | S    |
| 2109034 | E     | Planning of Assembly Systems (in German) (p. 747)                    | E. Haller  | 2 | 4  | W    |
| 2121350 | E     | Product Lifecycle Management (p. 765)                                | J. Ovtcharova  | 4 | 6  | W    |
| 2110032 | E     | Production Planning and Control (p. 770)                             | A. Rinn  | 2 | 4  | W    |
| 2110678 | E (P) | Production Techniques Laboratory (p. 772)                            | K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL | 3 | 4  | S    |
| 2145182 | E     | Project management in Global Product Engineering Structures (p. 782) | P. Gutzmer   | 2 | 4  | W    |
| 2110046 | E     | Productivity Management in Production Systems (p. 776)               | S. Stowasser   | 2 | 4  | S    |
| 2149667 | E     | Quality Management (p. 785)  | G. Lanza   | 2 | 4  | W    |
| 2149605 | E     | Simulation of production systems and processes (p. 813)              | K. Furmans, V. Schulze, P. Stock   | 4 | 5  | W    |
| 2109032 | E     | Simulation Aided Management (p. 815)                                 | P. Stock   | 2 | 4  | W    |

**Conditions:****Recommendations:** Recommended Compulsory Elective Subject:

2110031 Service Operations Management

2149605 Simulation of production systems and processes

2121350 Product Lifecycle Management

**Learning Outcomes:** The students acquire in the compulsory core subjects profound knowledge about the scientific theories, principles and methods of Production Management. The students can afterwards analyse, evaluate and design works tasks, work processes and work systems in consideration of technical, organisational as well as social conditions.

The students deepen in the elective courses specific fields of application. Afterwards they are able to analyse, evaluate and solve problems of this specific field of application.

After completion this module, the students are able

- to describe the goals of production and Production Management,
- to describe the prevailing requirements of the working world and the thereof resulting fields of application of Production Management and to give examples,
- to describe and to apply basic theories, methods and tools for the different fields of application of Production Management on a strategical, tactical and operational level,
- to plan and control the industrial process of production and adding value,
- to identify interfaces to adjacent disciplines (e.g. business economics, computer science, political economics),
- to evaluate production systems and the applied methods, to identify problems in a production system and to organise and configure a production system.

**Remarks:**

**SP 39: Production Technology**

| ID      | Cat   | Course  | Lecturer   | h | CP | Term |
|---------|-------|---|--|---|----|------|
| 2149657 | K     | Manufacturing Technology (p. 591)   | V. Schulze, F. Zanger  | 6 | 8  | W    |
| 2149902 | K     | Machine Tools and Industrial Handling (p. 880)  | J. Fleischer   | 6 | 8  | W    |
| 2150660 | K     | Integrated production planning (p. 659)   | G. Lanza   | 6 | 8  | S    |
| 2150904 | K     | Automated Manufacturing Systems (p. 514)  | J. Fleischer   | 6 | 8  | S    |
| 2149610 | K     | Global Production and Logistics - Part 1: Global Production (p. 610)                          | G. Lanza   | 2 | 4  | W    |
| 2149600 | K     | Global Production and Logistics - Part 2: Global Logistics (p. 612)                           | K. Furmans   | 2 | 4  | S    |
| 2149669 | E     | Materials and Processes for Body Lightweight Construction in the Automotive Industry (p. 694) | D. Steegmüller, S. Kienzle   | 2 | 4  | W    |
| 2149001 | E     | Production Technology and Management in Automotive (p. 774)                                   | V. Stauch, S. Peters   | 2 | 4  | W    |
| 2150681 | E     | Metal Forming (p. 857)  | T. Herlan  | 2 | 4  | S    |
| 2149655 | E     | Gear Cutting Technology (p. 867)  | M. Klaiber   | 2 | 4  | W    |
| 2150683 | E     | Control Technology (p. 822)   | C. Gönnheimer  | 2 | 4  | S    |
| 2149667 | E     | Quality Management (p. 785)   | G. Lanza   | 2 | 4  | W    |
| 2173560 | E (P) | Welding Lab Course, in groupes (p. 579)   | J. Hoffmeister   | 3 | 4  | W    |
| 2173565 | E     | Welding Technology I (p. 802)   | B. Spies   | 1 | 2  | W    |
| 2174570 | E     | Welding Technology II (p. 804)  | B. Spies   | 1 | 2  | S    |
| 2174575 | E     | Foundry Technology (p. 609)   | C. Wilhelm   | 2 | 4  | S    |
| 2174579 | E     | Technology of steel components (p. 842)   | V. Schulze   | 2 | 4  | S    |
| 2110678 | E (P) | Production Techniques Laboratory (p. 772)   | K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL | 3 | 4  | S    |
| 2117500 | E     | Energy efficient intralogistic systems (p. 568)   | F. Schönung  | 2 | 4  | W    |
| 2118097 | E     | Warehousing and distribution systems (p. 677)   | M. Schwab, J. Weiblen  | 2 | 4  | S    |
| 2145184 | E     | Leadership and Product Development (p. 680)   | A. Ploch   | 2 | 4  | W    |
| 2118085 | E     | Automotive Logistics (p. 683)   | K. Furmans   | 2 | 4  | S    |
| 2147161 | E     | Intellectual Property Rights and Strategies in Industrial Companies (p. 744)                  | F. Zacharias   | 2 | 4  | W/S  |
| 2109034 | E     | Planning of Assembly Systems (in German) (p. 747)   | E. Haller  | 2 | 4  | W    |
| 2121366 | E     | PLM in the Manufacturing Industry (p. 751)  | G. Meier   | 2 | 4  | W    |
| 2110032 | E     | Production Planning and Control (p. 770)  | A. Rinn  | 2 | 4  | W    |
| 2149605 | E     | Simulation of production systems and processes (p. 813)                                       | K. Furmans, V. Schulze, P. Stock   | 4 | 5  | W    |
| 2117095 | E     | Basics of Technical Logistics (p. 626)  | M. Mittwollen, Madzharov   | 4 | 6  | W    |
| 2117059 | EM    | Mathematical models and methods for Production Systems (p. 702)                               | K. Furmans, J. Stoll   | 4 | 6  | W    |
| 2110046 | E     | Productivity Management in Production Systems (p. 776)  | S. Stowasser   | 2 | 4  | S    |
| 2109042 | E     | Introduction to Industrial Production Economics (p. 647)                                      | S. Dürrschnabel  | 2 | 4  | W    |
| 2117096 | E     | Elements of Technical Logistics (p. 565)  | M. Mittwollen, Madzharov   | 3 | 4  | W    |

| ID      | Cat   | Course   | Lecturer                  | h | CP | Term |
|---------|-------|--|---------------------------|---|----|------|
| 2183640 | E (P) | Laboratory "Laser Materials Processing" (p. 761)                                       | J. Schneider, W. Pflöging | 3 | 4  | W/S  |
| 2149903 | E     | Design Project Machine Tools and Industrial Handling (p. 573)                          | J. Fleischer              | 2 | 4  | W    |
| 2113072 | E     | Development of Oil-Hydraulic Powertrain Systems (p. 780)                               | G. Geerling, I. Ays       | 2 | 4  | W    |
| 2149680 | E     | Project Mikro Manufacturing: Design and Manufacturing of Micro Systems (p. 779)        | V. Schulze, P. Hoppen     | 3 | 6  | W    |
| 2117097 | E     | Elements of Technical Logistics and Project (p. 566)                                   | M. Mittwollen, Madzharov  | 4 | 6  | W    |
| 2150601 | E     | Integrative Strategies in Production and Development of High Performance Cars (p. 656) | K. Schlichtenmayer        | 2 | 4  | S    |

**Conditions:** None

**Recommendations:** Recommended Compulsory Elective Subject:

2149605 Simulation of production systems and processes

**Learning Outcomes:** The students ...

- are able to analyze new situations and choose methods of production science target-oriented based on the analyses, as well as justifying their selection.
- are able to describe and compare complex production processes exemplarily.
- are able to generate new solutions in the field of production science under consideration of scientific theories, principles and methods.
- are able to solve tasks in the field of production science team oriented and proceed responsible and adequate to the situation.
- are able to integrate the results of others at the solution of given problems.
- have the ability to state results in written form developed in a team, and are able to interpret and present them with self-chosen methods.
- are able to identify, dissect and develop further systems and processes and apply given sets of criteria under consideration of technical, economic and social conditions.

**Remarks:** None

**SP 40: Robotics**

| ID      | Cat   | Course   | Lecturer  | h | CP | Term |
|---------|-------|--|---|---|----|------|
| 2105012 | K     | Adaptive Control Systems (p. 478)  | G. Bretthauer                                   | 2 | 4  | W    |
| 2106004 | K     | Computational Intelligence I (p. 541)  | G. Bretthauer, R. Mikut                         | 2 | 4  | S    |
| 2105015 | K     | Computational Intelligence II (p. 542)                                       | G. Bretthauer, R. Mikut                         | 2 | 4  | W    |
| 2106020 | K     | Computational Intelligence III (p. 543)                                      | R. Mikut  | 2 | 4  | S    |
| 2105011 | K     | Introduction into Mechatronics (p. 556)                                      | G. Bretthauer, A. Albers                        | 3 | 6  | W    |
| 2138340 | K     | Automotive Vision (p. 587)   | C. Stiller, M. Lauer                            | 2 | 4  | S    |
| 24152   | K     | Robotics I – Introduction to robotics (p. 796)                               | R. Dillmann, S. Schmidt-Rohr                    | 2 | 3  | W    |
| 24712   | K     | Robotics II - Learning and planning robots (p. 797)                          | R. Dillmann                                     | 2 | 3  | S    |
| 2138336 | K     | Behaviour Generation for Vehicles (p. 862)                                   | C. Stiller, T. Dang                             | 2 | 4  | S    |
| 2145150 | E     | Powertrain Systems Technology B: Stationary Machinery (p. 492)               | A. Albers, S. Ott                               | 2 | 4  | W    |
| 2137309 | E     | Digital Control (p. 546)   | M. Knoop  | 2 | 4  | W    |
| 2138341 | E     | Cognitive Automobiles - Laboratory (p. 668)                                  | C. Stiller, M. Lauer, B. Kitt                   | 2 | 4  | S    |
| 2146190 | E     | Lightweight Engineering Design (p. 672)                                      | A. Albers, N. Burkart                           | 2 | 4  | S    |
| 2137308 | E     | Machine Vision (p. 686)  | C. Stiller, M. Lauer                            | 4 | 8  | W    |
| 2105014 | E (P) | Laboratory mechatronics (p. 707)   | A. Albers, G. Bretthauer, C. Proppe, C. Stiller | 3 | 4  | W    |
| 2138326 | E     | Measurement II (p. 711)  | C. Stiller                                      | 2 | 4  | S    |
| 2145180 | E     | Methodic Development of Mechatronic systems (p. 713)                         | A. Albers, W. Burger                            | 2 | 4  | W    |
| 2105024 | E     | Modern Control Concepts I (p. 726)   | L. Gröll  | 2 | 4  | W    |
| 2141865 | E     | Novel actuators and sensors (p. 733)   | M. Kohl, M. Sommer                              | 4 | 6  | W    |
| 2147161 | E     | Intellectual Property Rights and Strategies in Industrial Companies (p. 744) | F. Zacharias                                    | 2 | 4  | W/S  |
| 2137306 | E (P) | Lab Computer-aided methods for measurement and control (p. 762)              | C. Stiller, P. Lenz                             | 3 | 4  | W    |
| 2162216 | E     | Computerized Multibody Dynamics (p. 791)                                     | W. Seemann                                      | 2 | 4  | S    |
| 2150683 | E     | Control Technology (p. 822)  | C. Gönnheimer                                   | 2 | 4  | S    |
| 2146192 | E     | Sustainable Product Engineering (p. 834)                                     | K. Ziegahn                                      | 2 | 4  | S    |
| 2106002 | E     | Computer Engineering (p. 839)  | G. Bretthauer                                   | 3 | 4  | S    |
| 2123375 | E (P) | Virtual Reality Laboratory (p. 871)  | J. Ovtcharova                                   | 3 | 4  | W/S  |
| 2117059 | EM    | Mathematical models and methods for Production Systems (p. 702)              | K. Furmans, J. Stoll                            | 4 | 6  | W    |
| 2150904 | E     | Automated Manufacturing Systems (p. 514)                                     | J. Fleischer                                    | 6 | 8  | S    |
| 24613   | E     | Localization of Mobile Agents (p. 685)                                       | U. Hanebeck, M. Baum                            | 3 | 4  | S    |
| 24635   | E     | Robotik III - Sensors in Robotics (p. 798)                                   | R. Dillmann, Meißner, Gonzalez, Aguirre         | 2 | 3  | S    |
| 2106033 | E     | System Integration in Micro- and Nanotechnology (p. 835)                     | U. Gengenbach                                   | 2 | 4  | S    |

**Conditions:****Recommendations:** Recommended courses:

- 2147175 CAE-Workshop

- 2105011 Einführung in die Mechatronik

**Learning Outcomes:** The Robotics offers extensive knowledge to develop, design and manufacture future intelligent robots. The following scientific disciplines are covered during the major Robotics:

- Control systems and control theory
- Actuators and sensors
- Mathematical and descriptive methods

The students of the major Robotics have the essential skills necessary to develop future robotic systems for modern applications.

**Remarks:**

**SP 41: Fluid Mechanics**

| ID      | Cat   | Course  | Lecturer                   | h | CP | Term |
|---------|-------|---|----------------------------|---|----|------|
| 2154446 | K     | Experimental Fluid Mechanics (p. 577)   | J. Kriegseis               | 2 | 4  | S    |
| 2153405 | K     | Finite Difference Methods for numerical solution of thermal and fluid dynamical problems (p. 545) | C. Günther                 | 2 | 4  | W    |
| 2154431 | K     | Finite Volume Methods for Fluid Flow (p. 595)   | C. Günther                 | 2 | 4  | S    |
| 2154437 | K     | Hydrodynamic Stability: From Order to Chaos (p. 645)  | A. Class                   | 2 | 4  | S    |
| 2157441 | K     | Computational Methods in Fluid Mechanics (p. 739)   | F. Magagnato               | 2 | 4  | W    |
| 2154449 | K     | Numerical Simulation of Turbulent Flows (p. 742)  | G. Grötzbach               | 3 | 4  | S    |
| 2154044 | K     | Scaling in fluid dynamics (p. 818)  | L. Bühler                  | 2 | 4  | S    |
| 2154200 | K     | (p. 603)  | F. Magagnato               | 2 | 4  | S    |
| 2169459 | E (P) | CFD-Lab using Open Foam (p. 539)  | R. Koch                    | 3 | 4  | W    |
| 2154432 | E     | Mathematical Methods in Fluid Mechanics (p. 699)  | A. Class, B. Frohnäpfel    | 2 | 4  | S    |
| 19228   | E     | Building- and Environmental Aerodynamics (p. 605)   | B. Ruck                    | 2 | 4  | S    |
| 2153425 | E     | Industrial aerodynamics (p. 646)  | T. Breitling               | 2 | 4  | W    |
| 2153429 | E     | Magnetohydrodynamics (p. 688)   | L. Bühler                  | 2 | 4  | W    |
| 2169458 | E     | Numerical simulation of reacting two phase flows (p. 741)   | R. Koch                    | 2 | 4  | W    |
| 2154407 | E     | Flows in rotating systems (p. 826)  | R. Bohning                 | 2 | 4  | S    |
| 2153406 | E     | Flows with chemical reactions (p. 827)  | A. Class                   | 2 | 4  | W    |
| 2154409 | E (P) | Numerical Fluid Mechanics with MATLAB (p. 743)  | B. Frohnäpfel              | 2 | 4  | S    |
| 2130934 | E     | Numerical Modeling of Multiphase Flows (p. 740)   | M. Wörner                  | 2 | 4  | S    |
| 2169470 | E     | Two-Phase Flow and Heat Transfer (p. 885)   | T. Schulenberg, M. Wörner  | 2 | 4  | W    |
| 2154436 | E     | Aerothermodynamics (p. 482)   | F. Seiler                  | 2 | 4  | S    |
| 2153410 | E     | Optical Flow Measurement: Fundamentals and Applications (p. 631)                                  | F. Seiler                  | 2 | 4  | W    |
| 2157445 | E     | Computational methods for the heat protection of a full vehicle (p. 845)                          | H. Reister                 | 2 | 4  | W    |
| 2154430 | E     | Introduction to modeling of aerospace systems (p. 558)  | G. Schlöffel               | 2 | 4  | S    |
| 2154445 | E (P) | Flow Simulations with OpenFOAM (p. 829)   | B. Frohnäpfel, C. Bruzzese | 2 | 4  | W    |
| 2154420 | E     | Aerodynamics (p. 481)   | F. Ohle                    | 2 | 4  | S    |
| 2157444 | E (P) | Introduction to numerical fluid dynamics (p. 560)   | B. Pritz                   | 2 | 4  | W    |
| 6221806 | E     | Fluid Mechanics of Turbulent Flows (p. 597)   | M. Uhlmann                 | 2 | 4  | S    |
| 2154401 | E     | Fluid-Structure-Interaction (p. 596)  | M. Mühlhausen              | 2 | 4  | S    |
| 2189910 | E     | Flows and Heat Transfer in Energy Technology (p. 828)   | X. Cheng                   | 2 | 4  | W    |
| 2157381 | E     | Windpower (p. 883)  | N. Lewald                  | 2 | 3  | W    |

**Conditions:**

**Recommendations:** Subjects are to be selected in such a way that numerical, experimental and theoretical methods are covered.

**Learning Outcomes:** After having completed this module the student is capable of deriving the relevant fluid mechanical equations and interpret the governed physics. He/She can describe the characteristic properties of fluids and can analyze flow scenarios. According to the chosen lectures, the student can capture flow scenarios with analytical, numerical and/or experimental means and is capable to evaluate the acquired results thoroughly.

**Remarks:** Within SP41 it is generally possible to also attend lectures of the Institute of Hydromechanics ([www.ifh.kit.edu](http://www.ifh.kit.edu)). These include

.

- turbulence model in fluid mechanics - RANS and LES
- numerical flow simulations I
- numerical flow simulations II
- experimental techniques I

Please contact Prof. Frohnäpfel ([bettina.frohnäpfel@kit.edu](mailto:bettina.frohnäpfel@kit.edu)) for further information if you are interested in this option.

**SP 43: Technical Ceramics and Powder Materials**

| ID      | Cat   | Course  | Lecturer                         | h | CP | Term |
|---------|-------|---|----------------------------------|---|----|------|
| 2126775 | K     | Structural Ceramics (p. 831)  | M. Hoffmann                      | 2 | 4  | S    |
| 2193010 | K     | Grundlagen der Herstellungsverfahren der Keramik und Pulvermetallurgie (p. 618) | R. Oberacker                     | 2 | 4  | W    |
| 2125757 | K     | Introduction to Ceramics (p. 664)   | M. Hoffmann                      | 4 | 6  | W    |
| 2125751 | E (P) | Practical Course Technical Ceramics (p. 763)                                    | R. Oberacker                     | 2 | 4  | W    |
| 2126749 | E     | Advanced powder metals (p. 784)   | R. Oberacker                     | 2 | 4  | S    |
| 2125763 | E     | Structural and phase analysis (p. 830)  | S. Wagner                        | 2 | 4  | W    |
| 2181711 | E     | Failure of structural materials: deformation and fracture (p. 865)              | P. Gumbsch, O. Kraft, D. Weygand | 2 | 4  | W    |
| 2126784 | E     | Functional Ceramics (p. 599)  | M. Hoffmann, M. Bäurer           | 2 | 4  | S    |
| 2126730 | E     | Ceramics Processing (p. 665)  | J. Binder                        | 2 | 4  | S    |

**Conditions:** none

**Recommendations:** Recommended compulsory elective subjects:

- Systematic Materials Selection
- Physics for Engineers
- Physical basics of laser technology

**Learning Outcomes:** The students acquire comprehensive and fundamental knowledge of preparation, processing and characterization of technical powders, their consolidation by various shaping techniques and the densification by sintering. They know the manifold possibilities of microstructural design of powdermetallurgical parts and are able to discuss the microstructure property relationships.

**Remarks:**

**SP 44: Technical Logistics**

| ID      | Cat | Course  | Lecturer                      | h | CP | Term |
|---------|-----|---|-------------------------------|---|----|------|
| 2117095 | KP  | Basics of Technical Logistics (p. 626)  | M. Mittwollen, Madzharov      | 4 | 6  | W    |
| 2117096 | K   | Elements of Technical Logistics (p. 565)  | M. Mittwollen, Madzharov      | 3 | 4  | W    |
| 2118087 | K   | Selected Applications of Technical Logistics (p. 503)                               | M. Mittwollen, Madzharov      | 3 | 4  | S    |
| 2118088 | K   | Selected Applications of Technical Logistics and Project (p. 504)                   | M. Mittwollen, Madzharov      | 4 | 6  | S    |
| 2117064 | E   | Application of technical logistics in modern crane systems (p. 493)                 | M. Golder                     | 2 | 4  | W    |
| 2118089 | E   | Application of technical logistics in sorting- and distribution technology (p. 494) | J. Föller                     | 2 | 4  | S    |
| 2117500 | E   | Energy efficient intralogistic systems (p. 568)                                     | F. Schönung                   | 2 | 4  | W    |
| 2138341 | E   | Cognitive Automobiles - Laboratory (p. 668)   | C. Stiller, M. Lauer, B. Kitt | 2 | 4  | S    |
| 2118097 | E   | Warehousing and distribution systems (p. 677)                                       | M. Schwab, J. Weiblen         | 2 | 4  | S    |
| 2117051 | E   | Material flow in logistic systems (p. 693)  | K. Furmans                    | 4 | 6  | W    |
| 2149667 | E   | Quality Management (p. 785)   | G. Lanza                      | 2 | 4  | W    |
| 2117061 | E   | Safety Engineering (p. 809)   | H. Kany                       | 2 | 4  | W    |
| 2138336 | E   | Behaviour Generation for Vehicles (p. 862)  | C. Stiller, T. Dang           | 2 | 4  | S    |
| 2118183 | EM  | IT-Fundamentals of Logistics (p. 662)   | F. Thomas                     | 2 | 4  | S    |
| 2150904 | E   | Automated Manufacturing Systems (p. 514)  | J. Fleischer                  | 6 | 8  | S    |
| 2117097 | E   | Elements of Technical Logistics and Project (p. 566)                                | M. Mittwollen, Madzharov      | 4 | 6  | W    |

**Conditions:** none

**Recommendations:** Recommended compulsory optional subjects:

- Mathematical Methods in Dynamics
- Simulation of production systems and processes
- Stochastics in Mechanical Engineering
- Modelling and Simulation
- Technical Logistics I

**Learning Outcomes:** Students are able to:

- Describe main functional elements of technical logistics,
- Determine the main parameters necessary for functionality,
- Combines those functional elements to solve material handling tasks appropriate, and
- Evaluate resulting material handling installations.

**Remarks:** none

**SP 45: Engineering Thermodynamics**

| ID      | Cat   | Course   | Lecturer            | h | CP | Term |
|---------|-------|--|---------------------|---|----|------|
| 2165515 | K     | Fundamentals of Combustion I (p. 627)  | U. Maas             | 2 | 4  | W    |
| 2166538 | K     | Fundamentals of combustion II (p. 628)   | U. Maas             | 2 | 4  | S    |
| 2167523 | K     | Modeling of Thermodynamical Processes (p. 723)   | R. Schießl, U. Maas | 3 | 6  | W/S  |
| 2167541 | E     | Selected chapters of the combustion fundamentals (p. 508)                              | U. Maas             | 2 | 4  | W/S  |
| 2165525 | E     | Mathematical models and methods in combustion theory (p. 701)                          | V. Bykov, U. Maas   | 2 | 4  | W    |
| 2134134 | E     | Analysis tools for combustion diagnostics (p. 712)                                     | U. Wagner           | 2 | 4  | S    |
| 2166543 | E     | Reduction methods for the modeling and the simulation of combustion processes (p. 795) | V. Bykov, U. Maas   | 2 | 4  | S    |
| 2153406 | E     | Flows with chemical reactions (p. 827)   | A. Class            | 2 | 4  | W    |
| 2169453 | E     | Thermal Turbomachines I (p. 848)   | H. Bauer            | 3 | 6  | W    |
| 2170476 | E     | Thermal Turbomachines II (p. 849)  | H. Bauer            | 3 | 6  | S    |
| 2167048 | E     | Combustion diagnostics (p. 861)  | R. Schießl, U. Maas | 2 | 4  | W/S  |
| 2133103 | E     | Fundamentals of Combustion Engines I (p. 629)  | H. Kubach, T. Koch  | 3 | 4  | W    |
| 2166534 | E     | Heatpumps (p. 872)   | H. Wirbser, U. Maas | 2 | 4  | S    |
| 2157445 | E     | Computational methods for the heat protection of a full vehicle (p. 845)               | H. Reister          | 2 | 4  | W    |
| 2154200 | E     | (p. 603)   | F. Magagnato        | 2 | 4  | S    |
| 2190913 | E (P) | Measurement technique for fluid mechanics (p. 710)                                     | X. Cheng            | 2 | 3  | S    |
| 2189910 | E     | Flows and Heat Transfer in Energy Technology (p. 828)                                  | X. Cheng            | 2 | 4  | W    |

**Conditions:** None.

**Recommendations:** Recommended Course:

- 22512 Heat- and Mass transfer

**Learning Outcomes:** After completion of SP 45 students are able to:

- apply the thermodynamic fundamentals of irreversible processes.
- explain the governing processes in combustion.
- outline the fundamentals of modeling and simulation of reacting flows.
- understand the working principle of technical systems applying thermodynamic processes and combustion.

**Remarks:**

**SP 46: Thermal Turbomachines**

| ID      | Cat   | Course   | Lecturer                          | h | CP | Term |
|---------|-------|--|-----------------------------------|---|----|------|
| 2169453 | KP    | Thermal Turbomachines I (p. 848)   | H. Bauer                          | 3 | 6  | W    |
| 2170476 | K     | Thermal Turbomachines II (p. 849)  | H. Bauer                          | 3 | 6  | S    |
| 2170454 | E     | Selected Topics in Aeronautics and Astronautics I (p. 505)                   | S. Wittig                         | 2 | 4  | S    |
| 2169486 | E     | Selected Topics in Aeronautics and Astronautics II (p. 506)                  | S. Wittig                         | 2 | 4  | W    |
| 2181745 | E     | Design of highly stresses components (p. 511)                                | J. Aktaa                          | 2 | 4  | W    |
| 2161252 | E     | Advanced Methods in Strength of Materials (p. 640)                           | T. Böhlke                         | 4 | 4  | W    |
| 2171486 | E (P) | Integrated measurement systems for fluid mechanics applications (p. 657)     | H. Bauer, Mitarbeiter             | 5 | 4  | W/S  |
| 2146190 | E     | Lightweight Engineering Design (p. 672)                                      | A. Albers, N. Burkardt            | 2 | 4  | S    |
| 2170463 | E     | Cooling of thermally high loaded gas turbine components (p. 676)             | H. Bauer, A. Schulz               | 2 | 4  | S    |
| 2161224 | E     | Machine Dynamics (p. 691)  | C. Proppe                         | 3 | 5  | S    |
| 2162220 | E     | Machine Dynamics II (p. 692)   | C. Proppe                         | 2 | 4  | W    |
| 2169458 | E     | Numerical simulation of reacting two phase flows (p. 741)                    | R. Koch                           | 2 | 4  | W    |
| 2147161 | E     | Intellectual Property Rights and Strategies in Industrial Companies (p. 744) | F. Zacharias                      | 2 | 4  | W/S  |
| 2173585 | E     | Fatigue of Metallic Materials (p. 806)                                       | K. Lang                           | 2 | 4  | W    |
| 2117061 | E     | Safety Engineering (p. 809)  | H. Kany                           | 2 | 4  | W    |
| 2154407 | E     | Flows in rotating systems (p. 826)   | R. Bohning                        | 2 | 4  | S    |
| 2161212 | E     | Vibration Theory (p. 840)  | A. Fidlin                         | 3 | 5  | W    |
| 2169462 | E     | Turbine and compressor Design (p. 854)                                       | H. Bauer, A. Schulz               | 2 | 4  | W    |
| 2170478 | E     | Turbo Jet Engines (p. 855)   | H. Bauer, A. Schulz               | 2 | 4  | S    |
| 2181715 | E     | Failure of Structural Materials: Fatigue and Creep (p. 863)                  | O. Kraft, P. Gumbusch, P. Gruber  | 2 | 4  | W    |
| 2181711 | E     | Failure of structural materials: deformation and fracture (p. 865)           | P. Gumbusch, O. Kraft, D. Weygand | 2 | 4  | W    |
| 2174574 | E     | Materials for Lightweight Construction (p. 877)                              | K. Weidenmann                     | 2 | 4  | S    |
| 2170490 | E     | Combined Cycle Power Plants (p. 602)   | T. Schulenberg                    | 2 | 4  | S    |
| 2170491 | E (P) | Simulator Exercises Combined Cycle Power Plants (p. 817)                     | T. Schulenberg                    | 2 | 2  | S    |
| 2154200 | E     | (p. 603)   | F. Magagnato                      | 2 | 4  | S    |

**Conditions:** None.

**Recommendations:** Recommended Course:

- 22512 Heat- and Mass transfer

**Learning Outcomes:** After completion of SP 46 students are able to:

- identify and quantify the specific requirements of different applications in the fields of energy technology, aeronautics, car and motor technology and process technology on thermal turbo machines,
- apply the basics of thermodynamics, fluid mechanics and of other generic disciplines to analyse and design turbo machines and their components,
- explain the governing processes in turbo machines such as compression, combustion and expansion,
- Recognise and exploit the potentials to further improve the economics and environmental friendliness of turbo machines, their components and in their interaction with the overarching systems, like power plant or airplane,

Explain the operational principle of turbo machines and the related generics.

**Remarks:**

**SP 47: Tribology**

| ID      | Cat | Course   | Lecturer                               | h | CP | Term |
|---------|-----|--|--|---|----|------|
| 2181114 | K   | Tribology (p. 853)   | M. Scherge, M. Dienwiebel              | 4 | 8  | W    |
| 2145181 | E   | Applied Tribology in Industrial Product Development (p. 487)     | A. Albers, W. Burger                   | 2 | 4  | W    |
| 2146180 | E   | Powertrain Systems Technology A: Automotive Systems (p. 491)     | A. Albers, S. Ott                      | 2 | 4  | S    |
| 2181740 | E   | Atomistic simulations and molecular dynamics (p. 500)            | P. Gumbsch                             | 2 | 4  | S    |
| 2194643 | E   | Constitution and Properties of Wear resistant materials (p. 501) | S. Ulrich                              | 2 | 4  | S    |
| 2173590 | E   | Polymer Engineering I (p. 752)                                   | P. Elsner                              | 2 | 4  | W    |
| 2142861 | E   | Nanotechnology for Engineers and Natural Scientists (p. 730)     | H. Hölscher, M. Dienwiebel, S. Walheim | 2 | 4  | W    |
| 2177618 | E   | Superhard Thin Film Materials (p. 832)                           | S. Ulrich                              | 2 | 4  | W    |
| 2181712 | E   | Nanotribology and -Mechanics (p. 732)                            | M. Dienwiebel, H. Hölscher             | 2 | 4  |      |

**Conditions:** none

**Recommendations:** preliminary knowlegde in mathematics, mechanics and materials science

**Learning Outcomes:** After attending the core subjects “tribology A” (2181113) and “tribology B” (2182139) the students have the following skills:

- They can describe the fundamental friction and wear mechanisms, which occur in tribologically stressed systems.
- They can evaluate the friction and wear behavior of tribological systems.
- They can explain the effects of lubricants and their most important additives.
- They can identify suitable approaches to optimize tribological systems.
- They explain the most important experimental methods for the measurement of friction and wear, and is able to use them for the characterisation of tribo pairs.
- They can choose suitable methods for the evaluation of roughness and topography from the nm-scale to the mm-scale and is able to interpret the determined values in respect to their effect on the tribological behavior.
- The can describe the most important surface-analytical methods and their physical principles for the characterization of tribologically stressed sliding surfaces.

The additional learning outcomes depend on which further lectures are selected and are explicitly described there.

**Remarks:**

**SP 49: Reliability in Mechanical Engineering**

| ID      | Cat   | Course   | Lecturer   | h | CP | Term |
|---------|-------|--|--|---|----|------|
| 2181715 | K     | Failure of Structural Materials: Fatigue and Creep (p. 863)                      | O. Kraft, P. Gumbsch, P. Gruber                  | 2 | 4  | W    |
| 2181711 | K     | Failure of structural materials: deformation and fracture (p. 865)               | P. Gumbsch, O. Kraft, D. Weygand                 | 2 | 4  | W    |
| 2182735 | E     | Application of advanced programming languages in mechanical engineering (p. 495) | D. Weygand                                       | 2 | 4  | S    |
| 2181740 | E     | Atomistic simulations and molecular dynamics (p. 500)                            | P. Gumbsch                                       | 2 | 4  | S    |
| 2181745 | E     | Design of highly stresses components (p. 511)                                    | J. Aktaa   | 2 | 4  | W    |
| 2162282 | E     | Introduction to the Finite Element Method (p. 551)                               | T. Böhlke  | 4 | 5  | S    |
| 2182732 | E     | Introduction to Theory of Materials (p. 554)                                     | M. Kamlah  | 2 | 4  | S    |
| 2178734 | E     | Introduction to the Mechanics of Composite Materials (p. 555)                    | Y. Yang  | 2 | 4  | S    |
| 2183716 | E (P) | FEM Workshop – constitutive laws (p. 589)  | K. Schulz, D. Weygand                            | 2 | 4  | W/S  |
| 2182731 | E (P) | Finite Element Workshop (p. 594)   | C. Mattheck, D. Weygand                          | 2 | 4  | S    |
| 2181720 | E     | Foundations of nonlinear continuum mechanics (p. 623)                            | M. Kamlah  | 2 | 4  | W    |
| 2181744 | E     | Size effects in micro and nanostructures materials (p. 614)                      | P. Gumbsch, D. Weygand, P. Gruber, M. Dienwiebel | 2 | 4  | W    |
| 2161252 | E     | Advanced Methods in Strength of Materials (p. 640)                               | T. Böhlke  | 4 | 4  | W    |
| 2146190 | E     | Lightweight Engineering Design (p. 672)  | A. Albers, N. Burkardt                           | 2 | 4  | S    |
| 2161254 | E     | Mathematical Methods in Strength of Materials (p. 697)                           | T. Böhlke  | 3 | 5  | W    |
| 2162280 | E     | Mathematical Methods in Structural Mechanics (p. 700)                            | T. Böhlke  | 3 | 5  | S    |
| 2181710 | E     | Mechanics in Microtechnology (p. 706)  | P. Gruber, C. Greiner                            | 2 | 4  | W    |
| 2183702 | E     | Modelling of Microstructures (p. 719)  | A. August, B. Nestler, D. Weygand                | 3 | 5  | W    |
| 2183703 | E     | Modelling and Simulation (p. 724)  | B. Nestler, P. Gumbsch                           | 3 | 5  | W/S  |
| 2149667 | E     | Quality Management (p. 785)  | G. Lanza   | 2 | 4  | W    |
| 2173585 | E     | Fatigue of Metallic Materials (p. 806)   | K. Lang  | 2 | 4  | W    |
| 2117061 | E     | Safety Engineering (p. 809)  | H. Kany  | 2 | 4  | W    |
| 2182740 | E     | Materials modelling: dislocation based plasticity (p. 879)                       | D. Weygand                                       | 2 | 4  | S    |
| 2181738 | E     | Scientific computing for Engineers (p. 884)                                      | D. Weygand, P. Gumbsch                           | 2 | 4  | W    |
| 2181730 | E     | Evaluation of welded joints (p. 523)   | P. Gumbsch, M. Farajian, Farajian, Majid         | 2 | 4  | W    |
| 2181750 | E     | Multi-scale Plasticity (p. 749)  | K. Schulz, C. Greiner                            | 2 | 4  | W    |

**Conditions:** none**Recommendations:** preliminary knowlegde in mathematics, mechanics and materials science**Learning Outcomes:** After attending the core subjects “failure of structural materials: fatigue and creep” (2181715) and “failure of structural materials: deformation and fracture”(2181711) the students will gain the following skills:

- They have the basic understanding of mechanical processes to explain the relationship between externally applied load and materials strength.
- They can explain the foundation of linear elastic fracture mechanics and is able to determine if this concept can be applied to a failure by fracture.
- They can describe the main empirical materials models for fatigue and creep as well as for deformation and fracture and can apply them.
- They have the physical understanding to describe and explain phenomena of failure.
- They can use statistical approaches for reliability predictions.
- They can use its acquired skills, to select and develop materials for specific applications.

The additional learning outcomes depend on which further lectures are selected and are explicitly described there.

**Remarks:**

**SP 50: Rail System Technology**

| ID      | Cat   | Course  | Lecturer                 | h | CP | Term |
|---------|-------|---|--------------------------|---|----|------|
| 2115919 | KP    | Rail System Technology (p. 519)   | P. Gratzfeld             | 2 | 4  | W/S  |
| 2115996 | KP    | Rail Vehicle Technology (p. 801)  | P. Gratzfeld             | 2 | 4  | W/S  |
| 2115995 | E     | Project Management in Rail Industry (p. 781)                              | P. Gratzfeld             | 2 | 4  | W    |
| 2114914 | E     | Railways in the Transportation Market (p. 544)                            | P. Gratzfeld             | 2 | 4  | S    |
| 2114346 | E     | Electric Rail Vehicles (p. 564)   | P. Gratzfeld             | 2 | 4  | S    |
| 2113102 | E     | Introduction to Automotive Lightweight Technology (p. 584)                | F. Henning               | 2 | 4  | W    |
| 2114053 | E     | Composites for Lightweight Design (p. 588)                                | F. Henning               | 2 | 4  | S    |
| 2105011 | E     | Introduction into Mechatronics (p. 556)                                   | G. Bretthauer, A. Albers | 3 | 6  | W    |
| 2138340 | E     | Automotive Vision (p. 587)  | C. Stiller, M. Lauer     | 2 | 4  | S    |
| 2162256 | E     | Computational Vehicle Dynamics (p. 790)                                   | C. Proppe                | 2 | 4  | S    |
| 2161217 | E (P) | Mechatronic Softwaretools (p. 819)  | C. Proppe                | 2 | 4  | W    |
| 6234801 | E     | Operation (p. 520)  | E. Hohnecker             | 2 | 3  | S    |
| 6234804 | E     | Operation Systems and Track Guided Infrastructure Capacity (p. 522)       | E. Hohnecker             | 2 | 3  | S    |
| 6234701 | E     | Track Guided Transport Systems - Technical Design and Components (p. 820) | E. Hohnecker             | 4 | 6  | W    |
| 2115916 | E     | Innovation Workshop: Mobility concepts for the year 2050 (p. 654)         | P. Gratzfeld             | 2 | 4  | W/S  |

**Conditions:****Recommendations:** none**Learning Outcomes:**

- The students understand relations and interdependencies between rail vehicles, infrastructure and operation in a rail system.
- They deduct the fundamental requirements for rail vehicles out of it and assess concepts of rail vehicles.
- They know about major systems in a rail vehicle and evaluate their fitness in specific fields of application.
- Supplementary lectures present further major aspects of a rail system.

**Remarks:**

**SP 51: Development of innovative appliances and power tools**

| ID      | Cat   | Course   | Lecturer  | h | CP | Term |
|---------|-------|--|---|---|----|------|
| 2145164 | KP    | Appliance and Power Tool Design (p. 607)                                     | S. Matthiesen                                   | 4 | 8  | W    |
| 2146190 | E     | Lightweight Engineering Design (p. 672)                                      | A. Albers, N. Burkardt                          | 2 | 4  | S    |
| 2145180 | E     | Methodic Development of Mechatronic systems (p. 713)                         | A. Albers, W. Burger                            | 2 | 4  | W    |
| 2147161 | E     | Intellectual Property Rights and Strategies in Industrial Companies (p. 744) | F. Zacharias                                    | 2 | 4  | W/S  |
| 2141865 | E     | Novel actuators and sensors (p. 733)   | M. Kohl, M. Sommer                              | 4 | 6  | W    |
| 2145182 | E     | Project management in Global Product Engineering Structures (p. 782)         | P. Gutzmer                                      | 2 | 4  | W    |
| 2145184 | E     | Leadership and Product Development (p. 680)                                  | A. Ploch  | 2 | 4  | W    |
| 2146193 | E     | Strategic Product Planning (p. 825)  | A. Siebe  | 2 | 4  | S    |
| 2174571 | E     | Design with Plastics (p. 671)  | M. Liedel                                       | 2 | 4  | S    |
| 2149667 | E     | Quality Management (p. 785)  | G. Lanza  | 2 | 4  | W    |
| 2147175 | E (P) | CAE-Workshop (p. 536)  | A. Albers, Assistenten                          | 3 | 4  | W/S  |
| 2105014 | E (P) | Laboratory mechatronics (p. 707)   | A. Albers, G. Bretthauer, C. Proppe, C. Stiller | 3 | 4  | W    |
| 2113072 | E     | Development of Oil-Hydraulic Powertrain Systems (p. 780)                     | G. Geerling, I. Ays                             | 2 | 4  | W    |

**Conditions:** SP 51 is not selectable in bachelor degree course.

It is selectable in masters course, depending on specialization.

Due to organizational reasons, the number of participants is limited. At the beginning of august, a registration form will be available at the IPEK website. In the case of too many applicants, a selection process will be taking place. An early application is advantageous.

**Recommendations:** CAE Workshop is recommended as elective course or complementary subject.

**Learning Outcomes:** Graduates are able to analyze and to synthesize complex technical products under consideration of customer, business and market demands. Specifically, they can address specific boundary conditions of devices and power tool manufacturers in power-tool development They and are able to take into account the resulting effects of complex product development projects: e.g. the production in large quantities, complexity of mechatronic solutions or workflow management of interdisciplinary and distributed development teams. The graduates are able to assess and optimize their work results in terms of quality, costs and user benefits. They have a holistic insight into the processes that are necessary for creating products in this specific context and thus are prepared for the technical and non-technical requirements of responsible positions in the team-oriented product development of devices and power tools.

**Remarks:**

**SP 53: Fusion Technology**

| ID      | Cat | Course   | Lecturer                  | h | CP | Term |
|---------|-----|--|---------------------------|---|----|------|
| 2169483 | K   | Fusion Technology A (p. 600)                           | R. Stieglitz              | 2 | 4  | W    |
| 2190492 | K   | Fusion Technology B (p. 601)                           | R. Stieglitz              | 2 | 4  | S    |
| 23271   | K   | Radiation Protection I: Ionising Radiation (p. 824)    | B. Breustedt, M. Urban    | 2 | 4  | W    |
| 2189473 | E   | Neutron physics of fusion reactors (p. 734)            | U. Fischer                | 2 | 4  | W    |
| 2153429 | E   | Magnetohydrodynamics (p. 688)                          | L. Bühler                 | 2 | 4  | W    |
| 2190496 | E   | Magnet Technology of Fusion Reactors (p. 687)          | W. Fietz, K. Weiss        | 2 | 4  | S    |
| 2169470 | E   | Two-Phase Flow and Heat Transfer (p. 885)              | T. Schulenberg, M. Wörner | 2 | 4  | W    |
| 2181745 | E   | Design of highly stresses components (p. 511)          | J. Aktaa                  | 2 | 4  | W    |
| 2194650 | E   | Materials under high thermal or neutron loads (p. 844) | A. Möslang, M. Rieth      | 2 | 4  | S    |
| 2130910 | E   | CFD for Power Engineering (p. 538)                     | I. Otic                   | 2 | 4  | S    |
| 2129901 | E   | Energy Systems I: Renewable Energy (p. 569)            | R. Dagan                  | 3 | 6  | W    |
| 2189904 | E   | Ten lectures on turbulence (p. 843)                    | I. Otic                   | 2 | 4  | W    |

**Conditions:**

**Recommendations:** The choice of this topic necessitates a substantial knowledge of the fundamental skills supplied in the bachelor curriculum, such as fluid mechanics, heat and mass transfer, technical thermodynamics, measurement and control technics, material sciences and design of technical components. Only this basis allows to get access to the often coupled multi-physics problems an enabling the elaboration of a sound solution.

Additional skills in physics and electrical engineering are appreciated

**Learning Outcomes:** Graduate in fusion technology acquire a fundamental knowledge of the fusion process and are enabled to deduce based on the physical boundary conditions technological and scientific engineering solutions to individual problems. Since fusion technology is intrinsically of interdisciplinary nature consisting of physics, mechanics, thermal-hydraulics, material sciences and electrical engineering incorporates, the focus of this topic is mainly devoted to allow for the understanding of the underlying physics and moreover to enable the students of couple the different disciplines. Here, mainly methodologies and solution approaches are communicated to the graduates with the goal to capture critical issues within multi-physics problems, to identify central challenges within the given problem and to enable them to elaborate engineering solution concepts. Aside from the analysis of the relevance/importance of aspects within a complex multi-physics problem graduates are prepared to take decisions based on a solid physics basis and to formulate solution approaches.

The reliable handling of different physical phenomena from different disciplines and the methodological capability to tackle multi-physics questions and to extract from them central core issues qualifies the graduates for a competent and successful career not only in fusion technology but also in neighboring fields such energy engineering as well as process, chemical and environmental engineering both in the research and development context but also in the project management.

**Remarks:**

**SP 54: Microactuators and Microsensors**

| ID      | Cat   | Course   | Lecturer   | h | CP | Term |
|---------|-------|--|--|---|----|------|
| 2141865 | K     | Novel actuators and sensors (p. 733)                         | M. Kohl, M. Sommer                               | 4 | 6  | W    |
| 2142881 | K     | Microactuators (p. 717)                                      | M. Kohl  | 2 | 4  | S    |
| 2141866 | E     | Actuators and sensors in nanotechnology (p. 483)             | M. Kohl  | 2 | 4  | W    |
| 2105011 | E     | Introduction into Mechatronics (p. 556)                      | G. Bretthauer, A. Albers                         | 3 | 6  | W    |
| 2105012 | E     | Adaptive Control Systems (p. 478)                            | G. Bretthauer                                    | 2 | 4  | W    |
| 2161217 | E (P) | Mechatronic Softwaretools (p. 819)                           | C. Proppe  | 2 | 4  | W    |
| 2106033 | E     | System Integration in Micro- and Nanotechnology (p. 835)     | U. Gengenbach                                    | 2 | 4  | S    |
| 2141861 | E     | Introduction to Microsystem Technology I (p. 621)            | A. Guber   | 2 | 4  | W    |
| 2142874 | E     | Introduction to Microsystem Technology II (p. 622)           | A. Guber   | 2 | 4  | S    |
| 2143882 | E     | Fabrication Processes in Microsystem Technology (p. 590)     | K. Bade  | 2 | 4  | W/S  |
| 2142861 | E     | Nanotechnology for Engineers and Natural Scientists (p. 730) | H. Hölscher, M. Dienwiebel, S. Walheim           | 2 | 4  | W    |
| 24152   | E     | Robotics I – Introduction to robotics (p. 796)               | R. Dillmann, S. Schmidt-Rohr                     | 2 | 3  | W    |
| 2162282 | E     | Introduction to the Finite Element Method (p. 551)           | T. Böhlke  | 4 | 5  | S    |
| 2181710 | E     | Mechanics in Microtechnology (p. 706)                        | P. Gruber, C. Greiner                            | 2 | 4  | W    |
| 2182732 | E     | Introduction to Theory of Materials (p. 554)                 | M. Kamlah  | 2 | 4  | S    |
| 2183702 | E     | Modelling of Microstructures (p. 719)                        | A. August, B. Nestler, D. Weygand                | 3 | 5  | W    |
| 2181744 | E     | Size effects in micro and nanostructures materials (p. 614)  | P. Gumbsch, D. Weygand, P. Gruber, M. Dienwiebel | 2 | 4  | W    |
| 2142897 | E     | Microenergy Technologies (p. 715)                            | M. Kohl  | 2 | 4  | S    |

**Conditions:** Mechanical Engineering: Major M&M

**Recommendations:** The major addresses students in the fields of mechanical engineering, mechatronics and information technology, material science and engineering, electrical engineering and industrial engineering. A comprehensive introduction is given in the basics and current developments.

Further information: reference ppt-presentation of the major

**Learning Outcomes:** - Knowledge of the principles of actuation and sensing including pros and cons

- Knowledge of the underlying concepts of materials science and technology on different lengths scales

- Explanation of layout and function of important actuators and sensors

- Calculation of important properties (time constants, forces, displacements, sensitivity, etc.)

- Development of a layout based on specifications

**Remarks:**

**SP 55: Energy Technology for Buildings**

| ID      | Cat | Course  | Lecturer     | h | CP | Term |
|---------|-----|---|--------------|---|----|------|
| 2157200 | E   | (p. 837)  | H. Henning   | 2 | 4  | W    |
| 2158201 | E   | (p. 838)  | H. Henning   | 2 | 4  | S    |
| 2157202 | E   | (p. 567)  | F. Schmidt   | 2 | 4  | W    |
| 2158206 | E   | (p. 725)  | F. Schmidt   | 2 | 4  | S    |
| 2157231 | E   | Adsorption Technology for Heat Transformation – Materials and Principles (p. 480) | S. Henninger | 2 | 4  | W    |
| 2158230 | E   | Adsorption Technology for Heat Transformation - Systems and Applications (p. 479) | L. Schnabel  | 2 | 4  | S    |
| 2157381 | E   | Windpower (p. 883)  | N. Lewald    | 2 | 3  | W    |

**Conditions:****Recommendations:**

**Learning Outcomes:** After completing the courses in SP 55 „Energy technology for buildings“ the students have achieved a comprehensive overview on the energy demand for air-conditioning of buildings (heating, cooling, humidification, dehumidification, ventilation) and the techniques for energy supply of buildings (heat, cold, locally generated electricity). They know the methods for evaluation of technologies regarding ecologic, criteria, primary energy and economic viability and they have the ability to apply these methods to concrete cases. They also have gained knowledge on all renewable energy technologies that are relevant for application in buildings, in particular solar thermal collectors and systems and photovoltaic systems as well as energy storage technologies that are applied in buildings (heat storage, batteries).

**Remarks:**

**SP 56: Advanced Materials Modelling**

| ID      | Cat | Course   | Lecturer            | h | CP | Term |
|---------|-----|--|---------------------|---|----|------|
| 2162344 | K   | Nonlinear Continuum Mechanics (p. 735)                 | T. Böhlke           | 2 | 5  | S    |
| 2181740 | K   | Atomistic simulations and molecular dynamics (p. 500)  | P. Gumbsch          | 2 | 4  | S    |
| 2174600 | E   | High Temperature Structural Materials (p. 639)         | M. Heilmaier        | 2 | 4  | W    |
| 2178123 | E   | Thin film and small-scale mechanical behavior (p. 851) | O. Kraft, P. Gruber | 2 | 4  | S    |

**Conditions:****Recommendations:****Learning Outcomes:****Remarks:**

| ID      | Cat     | Course   | Lecturer                  | h | CP | Term |
|---------|---------|--|---------------------------|---|----|------|
| 2133103 | KP      | Fundamentals of Combustion Engines I (p. 629)                                      | H. Kubach, T. Koch        | 3 | 4  | W    |
| 2133121 | KP      | Energy Conversion and Increased Efficiency in Internal Combustion Engines (p. 572) | T. Koch, H. Kubach        | 2 | 4  | W    |
| 2134131 | K       | Fundamentals of Combustion Engines II (p. 630)                                     | H. Kubach, T. Koch        | 3 | 4  | S    |
| 2134138 | K       | Fundamentals of catalytic exhaust gas aftertreatment (p. 619)                      | E. Lox                    | 2 | 4  | S    |
| 2134134 | K       | Analysis tools for combustion diagnostics (p. 712)                                 | U. Wagner                 | 2 | 4  | S    |
| 2134137 | K       | Engine measurement techniques (p. 728)   | S. Bernhardt              | 2 | 4  | S    |
| 2133108 | E       | Fuels and Lubricants for Combustion Engines (p. 521)                               | B. Kehrwald               | 2 | 4  | W    |
| 2134141 | E       | Gas Engines (p. 604)   | R. Golloch                | 2 | 4  | S    |
| 2134150 | E       | Analysis of Exhaust Gas und Lubricating Oil in Combustion Engines (p. 477)         | M. Gohl                   | 2 | 4  | S    |
| 2134139 | E       | Model based Application Methods (p. 722)   | F. Kirschbaum             | 3 | 4  | S    |
| 2134001 | E/P (P) | Engine Laboratory (p. 727)   | U. Wagner                 | 2 | 4  | S    |
| 2133112 | E       | Drive Systems and Possibilities to Increase Efficiency (p. 490)                    | H. Kollmeier              | 1 | 2  | W    |
| 2166538 | E       | Fundamentals of combustion II (p. 628)   | U. Maas                   | 2 | 4  | S    |
| 2113805 | E       | Automotive Engineering I (p. 616)  | F. Gauterin, H. Unrau     | 4 | 8  | W    |
| 2114835 | E       | Automotive Engineering II (p. 617)   | F. Gauterin, H. Unrau     | 2 | 4  | S    |
| 2113806 | E       | Vehicle Comfort and Acoustics I (p. 582)   | F. Gauterin               | 2 | 4  | W    |
| 2114825 | E       | Vehicle Comfort and Acoustics II (p. 583)  | F. Gauterin               | 2 | 4  | S    |
| 2158107 | E       | Technical Acoustics (p. 836)   | M. Gabi                   | 2 | 4  | S    |
| 2161224 | E       | Machine Dynamics (p. 691)  | C. Proppe                 | 3 | 5  | S    |
| 2162220 | E       | Machine Dynamics II (p. 692)   | C. Proppe                 | 2 | 4  | W    |
| 2181114 | E       | Tribology (p. 853)   | M. Scherge, M. Dienwiebel | 4 | 8  | W    |
| 2181745 | E       | Design of highly stresses components (p. 511)                                      | J. Aktaa                  | 2 | 4  | W    |
| 2150904 | E       | Automated Manufacturing Systems (p. 514)   | J. Fleischer              | 6 | 8  | S    |
| 2146192 | E       | Sustainable Product Engineering (p. 834)   | K. Ziegahn                | 2 | 4  | S    |
| 2147161 | E       | Intellectual Property Rights and Strategies in Industrial Companies (p. 744)       | F. Zacharias              | 2 | 4  | W/S  |
| 2145182 | E       | Project management in Global Product Engineering Structures (p. 782)               | P. Gutzmer                | 2 | 4  | W    |
| 2157445 | E       | Computational methods for the heat protection of a full vehicle (p. 845)           | H. Reister                | 2 | 4  | W    |
| 2113809 | E       | Automotive Engineering I (p. 517)  | F. Gauterin, M. Gießler   | 4 | 8  | W    |
| 2154200 | E       | (p. 603)   | F. Magagnato              | 2 | 4  | S    |

**Conditions:** The courses [2113805] and [2113809] can not be combined within this major field.

**Recommendations:** Recommended Courses:

- 22512 Heat and Mass Transfer
- 2165515 Fundamentals of combustion I

**Learning Outcomes:** After completion of SP 48 students are able to:

- transfer fundamentals of thermodynamics and technical combustion to applications of combustion engines
- name and describe applications

- describe and explain the working principle of combustion engine and its application in vehicles
- analyze and evaluate propulsion systems

**Remarks:**

## 6 Courses of the Major Fields

### 6.1 All Courses

#### Course: Analysis of Exhaust Gas und Lubricating Oil in Combustion Engines [2134150]

**Coordinators:** M. Gohl  
**Part of the modules:** (p. 475)[SP\_58\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

#### Learning Control / Examinations

Letter of attendance or oral exam (25 minutes, no auxillary means)

#### Conditions

none

#### Recommendations

Knowledge in the field of engine technology and measurement techniques is advantageous

#### Learning Outcomes

The Students can point out the challenges concerning the current emission standards in engine development. They can name and explain the basic principles of measurement techniques and methods to analyse exhaust gas components and components of engine oil. Hence, the students have the ability to choose the right methods for a given Problem and to interpret the results.

#### Content

The students get involved in the application of different measurement techniques in the field of exhaust gas and lubricating oil analysis. The functional principles of the systems as well as the application areas of the latter are discussed. In addition to a general overview of standard applications, current specific development and research activities are introduced.

#### Media

Lecture with Powerpoint slides

#### Literature

The lecture documents are distributed during the courses.

## Course: Adaptive Control Systems [2105012]

**Coordinators:** G. Bretthauer

**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral examination (1 hour)

Duration: 1 hours, also possible as an optional or part of a major subject

Auxiliary means: none

### Conditions

Measuring and Automatic Control

### Learning Outcomes

The students know different types, structures and operation of adaptive control systems. They are capable of setting up system equations theoretically and experimentally. By experimenting with examples students are prepared to apply adaptive control systems in practice.

### Content

Introduction: definitions, classification of adaptive control systems, objectives

Structures of adaptive control systems: overview, parameter-, structure- and signal-adaptive control systems, open-loop and closed loop ARS, ARS with reference/identification model, application

Modeling: methods, experimental conditions, experimental modeling, identification methods for single input single output systems and multi input multi output systems

Parameter adaptive control systems: definitions, design methods

### Literature

W. Weber. Adaptive Regelungssysteme, volume I, II. R. Oldenbourg, München, 1971.

## Course: Adsorption Technology for Heat Transformation - Systems and Applications [2158230]

**Coordinators:** L. Schnabel

**Part of the modules:** SP 55: Energy Technology for Buildings (p. 473)[SP\_55\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

#### Conditions

None.

### Learning Outcomes

This lecture provides an overview on the status of research and development for application of adsorption technology in buildings and describes the potential of this technology. A special focus is put on thermally driven heat pumps, thermally driven dehumidification systems and thermo-chemical energy storage. The lecture also provides the required fundamentals for design of components and systems.

The students are able to describe the potentials of application of sorption technology in buildings and they know the most sensitive design criteria. Methodologies for optimization of component design are part of the lecture. In particular the impact of the working pairs, the heat exchanger design (adsorber, evaporator, condenser) and the system integration on the overall system performance is shown.

The students have gained a basic understanding on different, partly opposing, optimization goal functions. They are able to present methods to determine transport coefficients and pressure losses and based on this they are able to do a basic design of single components of a sorption module as well as the overall sorption system.

### Content

- Overview on technical applications of sorption technology and technical solutions
- Comprehensive overview on the relevant material properties and system requirements (based on the lecture on fundamentals in the previous semester)
- Presentation and discussion of relevant evaluation criteria and methods for their (weighted) assessment
- Presentation of relevant fundamentals of heat exchanger design
- Detailed design description of adsorbers for open cycle and closed cycle application
- Detailed design description for evaporator and condenser
- Assessment of performance values for components and systems in different applications

### Literature

The students will receive scientific publications together with the lecture slides which refer to the topics presented in the particular lectures. The contents of these publications will be discussed in the subsequent lecture.

## Course: Adsorption Technology for Heat Transformation – Materials and Principles [2157231]

**Coordinators:** S. Henninger

**Part of the modules:** SP 55: Energy Technology for Buildings (p. 473)[SP\_55\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

#### Conditions

None.

### Learning Outcomes

Heat transformation processes experience a rising relevance within the field of building energy technology, e.g. in thermally driven heat pumps and chillers, for sorptive dehumidification or as thermochemical heat storage. This lecture shall convey the principles of sorptive heat transformation processes.

The students can describe sorption processes for heat transformation and name their fields of use and boundary conditions for their application. They have a good working knowledge of the fundamental thermodynamical models and descriptions of sorption processes. They can further classify the relevant working pairs regarding their physical and chemical properties and describe these properties. They can name measurement principles and methods for determining thermophysical properties such as specific surface area, pore volume, heat capacity, heat conductivity and sorption characteristics. Based on these models and properties, students are able to calculate heat and mass balances for adsorption cycles and are able to provide first estimates for the dimensioning of systems such as heat pump, chillers, dehumidification systems or thermochemical storage systems.

### Content

This lecture covers the fundamentals of sorptive heat transformation and is situated in the interdisciplinary field between mechanical engineering, physics and (chemical) process engineering.

Starting from thermodynamic foundations, working pairs and their thermodynamic properties will be covered. Relevant measuring principles and methods will be introduced in parallel. From this basis, the different aspects of heat and mass transfer in these systems will be introduced, leading to simple dimensioning calculations and estimates for system design.

- Introduction to sorption processes
- Thermodynamic foundations of sorption equilibria
- Thermophysical properties of different working pairs for sorption processes
- Measuring principles and methods
- Heat and mass transfer in adsorption systems
- Brief introduction into heat pumps, chillers and thermochemical heat storage

In the following semester, a consecutive lecture will be provided (by Dr.-Ing. Lena Schnabel) covering the components (evaporator, condenser, adsorber etc.), the description of heat and mass transport processes on the machine level and integration into building energy systems.

### Literature

- 1) Werner Kast, Adsorption aus der Gasphase, VCH
- 2) Diether Bathen, Adsorptionstechnik, Springer

**Course: Aerodynamics [2154420]****Coordinators:** F. Ohle**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral, 30 min,  
 auxiliary means: none

**Conditions**

none

**Recommendations**

Grundlagen der Strömungsmechanik, Mathematische Methoden der Strömungsmechanik

**Learning Outcomes**

The students can explain the fundamentals of aerodynamics as relevant for aeronautics and aviation. They can describe varying flight conditions phenomenologically and mathematically and are furthermore qualified to comparatively analyze varying design concepts.

**Content**

- Basics of aerodynamics
- Basic properties of flowing gas
- Potential Theory
- Airfoils (2-D wing)
- The finite (3-D) wing
- Airplane performance
- CFD
- Experimental verification

**Literature**

J.D. Anderson, jr.. Fundamentals of Aerodynamics, McGraw-Hill

E.L. Houghton. Aerodynamics for Engineering Students, Butterworth-Heinemann (Elsevier)

Schlichting, Gersten. Grenzschichttheorie, Springer

**Remarks**

Block course with limited number of participants, registration in the secretary's office required.

See details at [www.istm.kit.edu](http://www.istm.kit.edu).

**Course: Aerothermodynamics [2154436]****Coordinators:** F. Seiler**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

no auxiliary means

**Conditions**

none

**Learning Outcomes**

The students can describe the aerodynamic problems occurring during re-entry of space vehicles into the earth's atmosphere. They are able to explain the interrelation of high Mach number flow regimes and the co-occurring real gas effects (physics and chemistry of hot gases). Furthermore, they can discuss the link between the thermodynamics of hot air and the flow development at hypersonic flow conditions coupled with extreme heat flux phenomena in the frame of the term "Aerothermodynamics". Beyond the basic knowledge gained in the lecture on "Fluid Mechanics" the students are qualified to discuss all fundamentals as necessary to cover the fluid mechanics of re-entry flight trajectory of a space vehicle. They are able to distinguish the applicability of gaskinetic methods and continuum theory with respect to atmospheric altitude. The students are able to apply scaling laws as needed to transfer hypersonic flow to ground facilities (shock tunnels). They are qualified to explain the working principle of such tunnels and can explain the required measuring techniques based on recently achieved results.

**Content**

- Nature of a hypersonic flow
- Fundamentals of aerothermodynamics
- Problems during re-entry
- Flow regimes during re-entry
- Applied hypersonic research

**Literature**

H. Oertel jun.: Aerothermodynamik, Springer-Verlag, Berlin Heidelberg New York, 1994

F. Seiler: Skript zur Vorlesung über Aerothermodynamik

**Remarks**

Block course with limited number of participants, registration in the secretary's office required. See details at [www.istm.kit.edu](http://www.istm.kit.edu)

**Course: Actuators and sensors in nanotechnology [2141866]****Coordinators:** M. Kohl**Part of the modules:** SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

- (1) as optional subject in the major "Actuators and Sensors", oral, 30 minutes  
or  
(2) as optional subject, oral, 30 minutes

**Conditions**

Mechanical Engineering: Specialization M&amp;M

**Recommendations**

The lecture addresses students in the fields of mechanical engineering, mechatronics and information technology, materials science and engineering, physics, electrical engineering and economic sciences. A comprehensive introduction is given in the basics and current developments on the nanoscopic length scale.

**Learning Outcomes**

- Knowledge of the principles of actuation and sensing
- Knowledge of important fabrication technologies
- Explanation of typical properties (time constants, sensitivities, forces, etc.)
- Explanation of layout and function of the actuators and sensors

**Content**

- Physical principles of actuation and sensing
- Scaling and size effects
- Fabrication technologies
- Selected developments
- Applications

The lecture includes amongst others the following topics:

Nano technologies

Nano electro mechanical systems (NEMS)

Nano magneto mechanical and multiferroic systems

Polymer-based nano actuators

Nano motors, molecular systems

Adaptive nano optical systems

Nanosensors: concepts, materials, fabrication

Examples on different categories of materials and applications:

C-based, MeOx-based nano sensors

Physical, chemical, biological nano sensors

Multivariate data analysis / interpretation

**Literature**

- Lecture notes
- 2. Balzani, V., Credi, A., & Venturi, M., Molecular devices and machines: concepts and perspectives for the nanoworld, 2008
- „Nanowires and Nanobelts, - Materials, Properties and Devices -, Volume 2: Nanowires and Nanobelts of Functional Materials“, Edited by Zhong Lin Wang, Springer, 2003, ISBN 10 0-387-28706-X
- „Sensors Based on Nanostructured Materials“, Edited by Francisco J. Arregui, Springer, 2009, ISBN: 978-0-387-77752-8
- “Multivariate Datenanalyse – Methodik und Anwendungen in der Chemie”, R. Henrion, G. Henrion, Springer 1994, ISBN 3-540-58188-X

**Course: Actual topics of BioMEMS [2143873]****Coordinators:** A. Guber, Cattaneo, Giorgio**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

active participation and own presentation

**Conditions**

None.

**Recommendations**

Participation in lectures BioMEMS 1-3

**Learning Outcomes**

Knowledge in the actual activities in bio-medical and biological technologies under the view of micro technology. The student gets an overview on actual examples of new applications in BioMEMS.

After successful participation of this seminar the student is able to prepare a new topic in BioMEMS and to present it to an audience.

**Content****Media**

Written preparations from the participants.

**Course: Analysis and Design of Multisensor Systems [23064 ]****Coordinators:** G. Trommer, G. Trommer**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content****Literature****Elective literature:**

- Jan Wendel: Integrierte Navigationssysteme : Sensordatenfusion, GPS und Inertiale Navigation, München 2007.
- D. H. Titterton, J. L. Weston: Strapdown Inertial Navigation Technology.
- R. Brown, P. Hwang: Introduction to Random Signals and Applied Kalman Filtering, John Wiley & Sons.
- Farrell, J.; Barth, M.: The Global Positioning System & Inertial Navigation, McGraw-Hill, 1999, New York.
- Grewal, M.S. u.a.: Global Positioning Systems, Inertial Navigation and Integration, John Wiley & Sons, 2001, New York.

**Course: Low Temperature Technology [2158112]****Coordinators:** F. Haug**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination

duration: 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

none

**Recommendations**

Knowledge in Thermodynamics I is of advantage (however, no prerequisite)

**Learning Outcomes**

The lecture gives an introduction to the interdisciplinary field of low temperature technology (cryogenics) with emphasis on thermodynamics and process engineering. Fundamentals are explained followed by exercises and practical examples comprising industrial cryoplants. Where useful reference is made to cryogenic systems at CERN, the European Organization for high energy physics. Low temperature technology is a comparatively young engineering branch with future potential and is indispensable for basic research, space technology, some medical technologies, industry, superconductivity, research centres.

**Content**

1. Introduction to low temperature technology
2. The research centre CERN
3. Fundamentals (thermo-physical)
4. Low temperature properties of materials
5. Cryogens
6. Thermal insulation, storage, transfer of cryogenic fluids
7. Fundamentals (laws of thermodynamics)
8. Cycles and processes
9. Refrigerators and components
10. Instrumentation, automation
11. Examples of cryoplants (among others at CERN)
12. Cryocoolers
13. Production of extremely low temperatures

**Literature**

1. Technische Thermodynamik, beliebig
2. Tieftemperaturtechnologie, H. Frey und R. Haefer, VDI-Verlag, 1981
3. Handbook of Cryogenic Engineering, J. Weisend II, Verlag Taylor&Francis, 1998

## Course: Applied Tribology in Industrial Product Development [2145181]

**Coordinators:** A. Albers, W. Burger

**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 47: Tribology (p. 466)[SP\_47\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral exam

### Conditions

none

### Learning Outcomes

The goal of the lecture is to discuss tribological problems, tribological features and the tribological variety on examples of the automobile industry.

The students are able to ...

- define a tribological system.
- design a tribological system.
- discuss wear and damage impacts.
- explain measurement techniques to investigate tribological systems.
- show the limits of a tribological system.

### Content

Friction, Wear, Wear Measurement

Lubricant (Oil, Grease, etc.)

Hydrodynamic and elastohydrodynamic Lubrication

Design of Tribologic Working Surface Pairs

Technique of Measurement in Lubricated Contacts

Prevention of Maschine Failure

Protective Surface Layers

Journal Bearings, Roller Bearings

Gear Wheels and Transmissions

### Literature

The lecture script will be allocated at Ilias.

**Course: Applied Materials Modelling [2181614]****Coordinators:** P. Gumbsch, B. Nestler, A. August**Part of the modules:** SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 7            | 4              | Summer term | de                   |

**Learning Control / Examinations**

oral exam 35 minutes

no tools or reference materials

**Conditions**

compulsory preconditions: none

**Recommendations**

preliminary knowlegde in mathematics, physics and materials science

**Learning Outcomes**

The student can

- describe the physical foundation of particle based simulation methods and apply them to solve problems in materials science
- apply the method of phase-field modeling to simulate the microstructure formation during solidification
- use thermodynamic data bases and can couple appropriate energy functions with the microstructure simulations
- explain the influence of fluid flow on microstructure formation during solidification by using computational methods

**Content**

The lecture introduces the foundation of particle based simulation methods focussing on molecular dynamics.

In the part on mesoscopic methods, we introduce a fundamental phase-field model for the description of phase transition problems in two-phase material systems. The derivation of the dynamic evolution equation is based on an energy density functional. The various contributions of the governing equation are discussed. As an extension of the model, we couple a description of mass diffusion and treat different types of microstructure evolution in binary alloy systems such as dendrites, eutectics and peritectics. Since fluid flow has an important influence on the morphology of the solidifying structure, we elaborate a combined phase-field and fluid flow model and apply it to selected systems.

**Media**

black board, beamer, script, computer exercise

**Literature**

1. D. Frenkel, B. Smit: Understanding Molecular Simulation: From Algorithms to Applications, Academic Press, 2001
2. W. Kurz, D.J. Fisher: Fundamentals of Solidification, Trans Tech Publications, 1998
3. P. Haupt: Continuum Mechanics and Theory of Materials, Springer, 1999
4. M. P. Allen, D. J. Tildesley: Computer simulation of liquids, Clarendon Press, 1996

**Remarks**

From 2015 on the lecture/lab will be offered during summer term!

In winter term the lecture/lab will be offered for the last time during winter term 2014/2015!

**Course: Drive Train of Mobile Machines [2113077]****Coordinators:** M. Geimer, M. Scherer**Part of the modules:** SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

**Conditions**

None.

**Recommendations**

- general basics of mechanical engineering
- basic knowledge in hydraulics
- interest in mobile machines

**Learning Outcomes**

Get to know all relevant aspects and components of a drive train of a mobile machine and also the construction of various drive trains. Knowing and understanding interactions and independancies of components on a basic level.

**Content**

In this course will be discussed the different drive train of mobile machinerys. The fokus of this course is:

- improve knowledge of fundamentals
- mechanical gears
- torque converter
- hydrostatic drives
- continuous variable transmission
- electrical drives
- hybrid drives
- axles
- terra mechanic

**Media**

projector presentation

**Literature**

download of scriptum via ILIAS

**Course: Drive Systems and Possibilities to Increase Efficiency [2133112]**

**Coordinators:** H. Kollmeier  
**Part of the modules:** (p. 475)[SP\_58\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination, time duration 30 min., no aids

**Conditions**

none

**Recommendations**

Verbrennungsmotoren A

**Learning Outcomes**

The student has an overview about possibilities for increasing the efficiency of propulsion systems. He understands the basics of waste heat recovery and knows the required technology therefore. He has an overview about systems for storage electrical energy, heat energy and mechanical energy. The student understands the technical contexts of combined propulsions systems of internal combustion engine and electric motor/generator. The student understands the necessary of lightweight construction systems and knows the material basics therefore.

**Content**

The students attend to propulsion systems and possibilities for increasing efficiency and get an overview about the demand of energy of stationary and mobile propulsion systems. Furthermore they get an overview about possibilities for increasing efficiency by the use of storage systems, systems of waste heat recovery and lightweight construction systems. There is also a view on complete systems for increasing efficiency as combined heat and power plant and hybrid propulsion systems.

**Media**

Lecture with powerpoint slides

**Literature**

Download of powerpoint slides

**Remarks**

none

**Course: Powertrain Systems Technology A: Automotive Systems [2146180]****Coordinators:** A. Albers, S. Ott**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 47: Tribology (p. 466)[SP\_47\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The type of examination (written or oral) will be announced at the beginning of the lecture.

written examination: 60 min duration

oral examination: 20 min duration

**Conditions**

none

**Recommendations**

Power Train Systems Technology B: Stationary Machinery

**Learning Outcomes**

The student acquires the basic skills which are necessary to design energy-efficient and comfortable automotive powertrain solutions.

**Content**

Powertrain System

Driver System

Environment System

System Components

Development Process

**Literature**

Kirchner, E.; "Leistungsübertragung in Fahrzeuggetrieben: Grundlagen der Auslegung, Entwicklung und Validierung von Fahrzeuggetrieben und deren Komponenten", Springer Verlag Berlin Heidelberg 2007

Naunheimer, H.; "Fahrzeuggetriebe: Grundlagen, Auswahl, Auslegung und Konstruktion", Springer Verlag Berlin Heidelberg 2007

**Course: Powertrain Systems Technology B: Stationary Machinery [2145150]****Coordinators:** A. Albers, S. Ott**Part of the modules:** SP 20: Integrated Product Development (p. 432)[SP\_20\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The type of examination (written or oral) will be announced at the beginning of the lecture.

written examination: 60 min duration

oral examination: 20 min duration

**Conditions**

none

**Recommendations**

Powertrain Systems Technology A: Automotive Systems

**Learning Outcomes**

The student acquires the basic skills which are necessary to design energy-efficient and secure solutions for the design of stationary powertrain applications.

**Content**

Powertrain System  
 Operator System  
 Environment System  
 System Components  
 Development Process

**Literature**

VDI-2241: "Schaltbare fremdbetätigte Reibkupplungen und -bremsen", VDI Verlag GmbH, Düsseldorf  
 Geilker, U.: "Industriekupplungen - Funktion, Auslegung, Anwendung", Die Bibliothek der Technik, Band 178, verlag moderne industrie, 1999

**Course: Application of technical logistics in modern crane systems [2117064]****Coordinators:** M. Golder**Part of the modules:** SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral, approx. 20min, appointment after acknowledgement

**Conditions**

none

**Recommendations**

technical interest; Beneficial: Knowledge of the lecture 'Technical logistics I, basics'

**Learning Outcomes**

Students are able to:

- Dimension modern crane installations and transfer this approach to other material handling installations and
- Judge about the confirmity of the system by using relevant standards and set of rules.

**Content**

- Basics of modern crane construction
- Characteristics of application, classification
- Configuration, dimensioning, consideration of costs
- Relevant rules and standards
- Modern concepts of crane control and drives

**Media**

presentations, black board

**Literature**

None.

**Remarks**

none

## Course: Application of technical logistics in sorting- and distribution technology [2118089]

**Coordinators:** J. Föllner

**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach], SP 19: Information Technology of Logistic Systems (p. 431)[SP\_19\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral 30 min

### Conditions

None.

### Recommendations

None.

### Learning Outcomes

Students are able to:

- Describe and classify basics and characteristics of application of sorting and distribution of goods,
- Solve drive and control tasks with appropriate concept selection,
- Design systems with appropriate calculation methods and evaluate them financially, and
- Judge about the confirmity of the system by using relevant standards and set of rules.

### Content

Basics of goods sorting and distribution technology, employment characteristics, classification, interpretation, dimensioning, costs considerations. Relevant control, modern sets of rules and propulsion principles

### Media

presentations, black board

### Literature

None.

### Remarks

none

## Course: Application of advanced programming languages in mechanical engineering [2182735]

**Coordinators:** D. Weygand

**Part of the modules:** SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

None.

### Learning Outcomes

The student can

- utilise the programming language Fortran 95 and Fortran 2003 to implement simple numerical simulations
- apply a script languages awk resp. python for data treatment

### Content

This lecture gives an introduction to advances programming and scripting languages and numerical methods under UNIX/Linux:

- \* Fortran 95/2003
  - structure of source code
  - programming
  - compiling
  - debugging
  - parallelization with OpenMP
- \* numerical methods
- \* script languages: Python, awk
- \* visualisation

### Literature

1. fortran 95/2003 explained, M. Metcalf, J. Reid, M. Cohen, Oxford University Press 2004.
2. Intel Fortran compiler handbook.

## Course: Human Factors Engineering I [2109035]

**Coordinators:** B. Deml

**Part of the modules:** SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach], SP 16: Industrial Engineering (p. 429)[SP\_16\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Compulsory Core Subject:** oral exam

**Elective Subject:** oral exam (ca. 30 min)

**Compulsory Optional Subject:** written exam (60 min)

**Optional Subject:** oral exam (ca. 30 min)

The exams are only offered in German!

### Conditions

- The exams “Arbeitswissenschaft I (2109035)” and “Ergonomie und Arbeitswirtschaft (2109029)” are mutually exclusive.
- The exams “Arbeitswissenschaft I (2109035)” and “Arbeitsschutz und Arbeitsrecht (2109024)” are mutually exclusive.
- The exams “Arbeitswissenschaft I (2109035)” and “Arbeitswissenschaft (2109026)” are mutually exclusive.

### Recommendations

- Willingness to learn interdisciplinarily (Product design, Legal regulations Work physiology, Work psychology ...)
- Basic knowledge of Production Management is usefull

### Learning Outcomes

After completion the lecture, the students are able

- to classify basics of human work and to apply basic research methods of Human Factors Engineering,
- to evaluate and design work places following the goals of Human Factors Engineering under consideration of psychological, physiological, anthropometric, safety-related, organisational as well as technological aspects,
- evaluate and configure work environments following the goals of Human Factors Engineering under consideration of noise, illumination, climate and mechanical vibrations,
- to classify and apply basic theories and methods of Human Factors Engineering. They are able to evaluate a work place and to derive corresponding wage concepts,
- to rate problems of labor-law and to describe the organisation of the representation of interests in the German working world.

### Content

1. Introduction
2. Basics of human performance
3. Research methods of Human Factors Engineering
4. Design of workplaces
5. Design of working environment

6. Industrial Engineering

7. Labour legislation and Representation of interest groups

**Literature**

**Learning material:**

Handout and literature online ILIAS.

**Literature:**

- SCHLICK, Christopher; BRUDER, Ralph; LUCZAK, Holger: Arbeitswissenschaft. Heidelberg u.a.: Springer, 3rd edition 2010.

Please refer to the latest edition.

**Course: Human Factors Engineering II [2109036]****Coordinators:** B. Deml**Part of the modules:** SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations****Compulsory Core Subject:** oral exam**Elective Subject:** oral exam (ca. 30 min)**Optional Subject Economics/Law:** written exam (60 min)**Optional Subject:** oral exam (ca. 30 min)

The exams are only offered in German!

**Conditions**

- The exams “Arbeitswissenschaft II (2109036)” and “Arbeitsschutz und Arbeitsrecht (2109024)” are mutually exclusive.
- The exams “Arbeitswissenschaft II (2109036)” and “Arbeitswissenschaft (2109026)” are mutually exclusive.

**Learning Outcomes**

After completion the lecture, the students are able

- to classify basics of the research within work organisation and to apply basic research methods of Human Factors Engineering. They know actual trends of work organisation.
- to apply fundamental methods of employee selection, personnel development and employee appraisal. They know basic theories of work satisfaction and motivation.
- to consider important psychological aspects of teams (e.g. interaction, communication). They know fundamental theories about leadership.
- to apply and evaluate methods of human-resource allocation and the fundamental basics of departmental, process and production organisation.

**Content**

1. Introduction
2. Basics of work organisation
3. Research methods of work organisation
4. Individual person
5. Group
6. Organisation

**Literature****Learning material:**

Handout and literature online ILIAS.

**Literature:**

- SCHLICK, Christopher; BRUDER, Ralph; LUCZAK, Holger: Arbeitswissenschaft. Heidelberg u.a.: Springer, 3rd edition 2010.

Please refer to the latest edition.

**Course: Human Factors Lab [2109033]****Coordinators:** B. Deml**Part of the modules:** SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

- Compulsory attendance during the whole lecture
- Colloquium in the beginning of each laboratory
- No exam

**Conditions**

- Compulsory attendance during the whole lecture
- Limited number of participants

**Recommendations**

- Willingness to learn interdisciplinarily (Technology, Economy, Legal regulations, Informatics . . .)
- Knowledge of Work Science is necessary

**Learning Outcomes**

After completion this lab, the students are able

- to describe and apply empirical research methods of Human Factors Engineering,
- to describe fundamental measuring methods, measuring instruments as well as software for specific problems of Human Factors Engineering and to apply them for solving corresponding problems.
- to evaluate micro and macro work systems, to identify possible problems within and to design and configure work systems.

**Content**

1. Introduction to statistics
2. Basics of human work
3. Configuration of work places
4. Configuration of work environment
5. Time studies
6. Work organisation
7. Enterprise simulation

**Literature**

Handout and literature online ILIAS.

**Course: Atomistic simulations and molecular dynamics [2181740]****Coordinators:** P. Gumbsch**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 56: Advanced Materials Modelling (p. 474)[SP\_56\_mach], SP 47: Tribology (p. 466)[SP\_47\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

oral exam 30 minutes

**Conditions**

compulsory preconditions: none

**Recommendations**

preliminary knowlegde in mathematics, physics and materials science

**Learning Outcomes**

The student can

- describe the physical foundation of particle based simulation method (e.g. molecular dynamics)
- apply particle based simulation methods to problems in materials science

**Content**

The lecture introduces the foundation of particle based simulation methods focussing on molecular dynamics:

1. Introduction
2. Physics of Materials
3. MD Basics, Atom-Billard
  - \* particle, position, energy, forces, pair potentials
  - \* initial and boundary conditions
  - \* time integration
4. algorithms
5. static, dynamic, thermodynamic
6. MD output
7. interaction between particles
  - \* pair potential – many body potentials
  - \* principles of quantum mechanics
  - \* tight binding methods
  - \* dissipative particle dynamics
8. application of particle based methods

**Literature**

1. Understanding Molecular Simulation: From Algorithms to Applications, Daan Frenkel and Berend Smit (Academic Press, 2001)
2. Computer simulation of liquids, M. P. Allen and Dominic J. Tildesley (Clarendon Press, Oxford, 1996)

**Course: Constitution and Properties of Wear resistant materials [2194643]****Coordinators:** S. Ulrich**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 47: Tribology (p. 466)[SP\_47\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination (30 min)

no tools or reference materials

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

Basic understanding of constitution of wear-resistant materials, of the relations between constitution, properties and performance, of principles of increasing of hardness and toughness of materials as well as of the characteristics of the various groups of wear-resistant materials.

**Content**

introduction

materials and wear

unalloyed and alloyed tool steels

high speed steels

stellites and hard alloys

hard materials

hard metals

ceramic tool materials

superhard materials

new developments

**Literature**

Laska, R. Felsch, C.: Werkstoffkunde für Ingenieure, Vieweg Verlag, Braunschweig, 1981

Schedler, W.: Hartmetall für den Praktiker, VDI-Verlage, Düsseldorf, 1988

Schneider, J.: Schneidkeramik, Verlag moderne Industrie, Landsberg am Lech, 1995

Copies with figures and tables will be distributed

**Course: Constitution and Properties of Protective Coatings [2177601]****Coordinators:** S. Ulrich**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination (30 min)

no tools or reference materials

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

Transfer of the basic knowledge of surface engineering, of the relations between constitution, properties and performance, of the manifold methods of modification, coating and characterization of surfaces.

**Content**

introduction and overview

concepts of surface modification

coating concepts

coating materials

methods of surface modification

coating methods

characterization methods

state of the art of industrial coating of tools and components

new developments of coating technology

**Literature**

Bach, F.-W.: Modern Surface Technology, Wiley-VCH, Weinheim, 2006

Copies with figures and tables will be distributed

**Course: Selected Applications of Technical Logistics [2118087]****Coordinators:** M. Mittwollen, Madzharov**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

after each lesson period; oral / written (if necessary) =&gt; (look at "Studienplan Maschinenbau", latest version)

**Conditions**

look at Empfehlungen (en)

**Recommendations**

GTL/ESTL should be visited in advance, knowledge out of GTL/ESTL preconditioned

**Learning Outcomes**

Students are able to:

- Model the dynamic behaviour of material handling systems and based on this calculate the dynamical behaviour and
- Transfer this approach autonomous to further, different material handling installations and
- Discuss the knowledge with subject related persons.

**Content**

design and dimension of machines from intralogistics // static and dynamic behaviour // operation properties and specifics // visit of real intralogistic system

Inside practical lectures: sample applications and calculations in addition to the lectures

**Media**

supplementary sheets, projector, blackboard

**Literature**

Recommendations during lessons

**Remarks**

-

**Course: Selected Applications of Technical Logistics and Project [2118088]****Coordinators:** M. Mittwollen, Madzharov**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Summer term | de                   |

**Learning Control / Examinations**

Lesson: after each lesson period; oral / written (if necessary) =&gt; (look at "Studienplan Maschinenbau"); (counts two-thirds);

Project: presentation, marked (counts one third)

**Conditions**

none

**Recommendations**

GTL/ESTL should be visited in advance, knowledge out of GTL/ESTL preconditioned

**Learning Outcomes**

Students are able to:

- Model the dynamic behaviour of material handling systems and based on this calculate the dynamical behaviour and
- Transfer this approach autonomous to further, different material handling installations,
- Discuss the knowledge with subject related persons and
- Judge about systems in place and justify it in front of subject related persons.

**Content**

design and dimension of machines from intralogistics // static and dynamic behaviour // operation properties and specifics // visit of real intralogistic system // self manufactured project report

Inside practical lectures: sample applications and calculations in addition to the lectures

Self manufacturing of a project report to recesses the topic.

**Media**

supplementary sheets, projector, blackboard

**Literature**

Recommendations during lessons

**Course: Selected Topics in Aeronautics and Astronautics I [2170454]****Coordinators:** S. Wittig**Part of the modules:** SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

Supporting material: none

**Conditions**

Basic principles of mathematics, thermodynamics, fluid mechanics, mechanics

**Learning Outcomes**

The students are able to:

- analyse space systems
- comment on the integration of air traffic in the transport system due to the mobility requirements
- explain the physical-technical basics and judge the design and application of space vehicles and air transport concerning economic and ecological issues
- name the main components of various systems and application fields (e.g. earth observation, communication, space exploration, manned spaceflight) and explain their function
- define and analyse the requirements and design principles for aircrafts / aircraft fleets

**Content**

Central topics are the analysis of space systems and of the air traffic with its impact on modern mobility requirements. The understanding of the fundamentals - physical and technological - is essential for the design and application of space vehicles as well as of an economically and ecologically efficient air transport. Based on recent developments the main components of the various systems and their design principles are introduced.

In the fall/winter semester an additional lecture course is offered.

**I. Space Systems**

Applications

Space Programms

Economical Aspects

Main Components

Influence Parameters

Space Missions

Launches

Satellites

**II. Air Transport**

Development: State of the art

Economical Aspects

Aircraft Design and Development

Aerodynamics

New Materials

Future Developments

**Literature**

Messerschmidt, Ernst: Raumfahrt-systeme, Springer-Verlag 2005

Griffin, Michael D.: Space Vehicle Design; AIAA Education Series 2004

Hünecke, Klaus: Die Technik des modernen Verkehrsflugzeuges, Motorbuch-Verlag 2004

**Course: Selected Topics in Aeronautics and Astronautics II [2169486]****Coordinators:** S. Wittig**Part of the modules:** SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

Supporting material: none

**Conditions**

Basic Principles of Mathematics, Fluid Mechanics, Thermodynamics, Mechanics

**Learning Outcomes**

The students possess the ability to:

- explain and evaluate the design principles of civil aircrafts
- analyse the requirements for civil aircrafts
- derive design and construction principles for aircraft fuselage and engines
- discuss (transient) loads during operation
- describe and apply the basic principles of orbital mechanic and maneuverability of satellites in space
- discuss launcher design and re-entry problems with ground and space segments

**Content**

The main topics in the first half of the course is the civil aircraft design. Based on the analysis of the general requirements, design principles for aircraft fuselage and the engines are introduced. Various - including unsteady - loads during operation are discussed. The second part is directed towards the basic principles of orbital mechanic and maneuverability of satellites in space . Launcher design and re-entry problems with ground and space segments are introduced. In the spring/summer semester an additional lecture-course is offered.

**I. Aircraft Design**

Mission Envelope

Aircraft Engines

Design Concepts

Aerodynamic Loads

**II. Space Systems and**

Satellites

Orbital Mechanics

Orbital Transfer

Rocket Systems

Ground- and Space Segements

Re-entry

Future Missions

**Literature**

Hünecke, Klaus: Die Technik des modernen Verkehrsflugzeuges, Motorbuch-Verlag, 2004

Hull, David, G.: Fundamentals of air-plane flight mechanics; Springer 2007

Messerschmid, Ernst: Raumfahrt-systeme, Springer-Verlag 2005

Griffin, Michael D.: Space Vehicle Design, AIAA Education Series 2004

**Course: Selected Topics on Optics and Microoptics for Mechanical Engineers [2143892]****Coordinators:** T. Mappes**Part of the modules:** SP 33: Microsystem Technology (p. [450](#))[SP\_33\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content**

**Course: Selected chapters of the combustion fundamentals [2167541]****Coordinators:** U. Maas**Part of the modules:** SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The attendance of this course enables students to gain a deeper understanding of the mechanisms involved in the chemistry of combustion, droplet and spray combustion and the statistical modelling of turbulent combustion.

**Content**

Depending on the lecture: Fundamentals of chemical kinetics, of statistical modeling of turbulent flames or of droplet and spray combustion.

**Media**

Blackboard and Powerpoint presentation

**Literature**

Lecture notes on fundamentals of combustion (Prof. U. Maas)

Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation, authors: U. Maas, J. Warnatz, R.W. Dibble, Springer-Lehrbuch, Heidelberg 1996

**Course: Selected Problems of Applied Reactor Physics and Exercises [2190411]****Coordinators:** R. Dagan**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral exam, 30 min.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The students

- have solid understanding of the basic reactor physics
- are able to estimate processes of growth and decay of radionuclides; out of it, they can perform dose calculation and introduce their biological hazards
- can calculate the relationship of basic parameters which are needed for a stable reactor operation
- understand important dynamical processes of nuclear reactors.

**Content**

- Nuclear energy and forces
- Radioactive decay
- Nuclear processes
- Fission and the importance of delayed neutrons
- Basics of nuclear cross sections
- Principles of chain reaction
- Static theory of mono energetic reactors
- Introduction to reactor kinetic
- student laboratory

**Literature**

K. Wirtz Basics of Reactor technic Par I, II, Technic School Karlsruhe 1966 (in German)

D. Emendorfer. K.H. Höcker Theory of nuclear reactions, BI- Hochschultaschenbücher 1969 (in German)

J. Duderstadt and L. Hamilton, Nuclear reactor Analysis, J. Wiley &amp; Sons, Inc. 1975.

**Course: Design of combustion chamber in gas turbines (Project) [22509]****Coordinators:** N. Zarzalis**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

**Learning Control / Examinations**

Certificate

**Conditions**

Engineering Thermodynamics, Fluid Mechanics, Heat and Mass Transfer, Construction

**Recommendations**

None.

**Learning Outcomes****Content****Remarks**

None.

**Course: Design of highly stresses components [2181745]****Coordinators:** J. Aktaa**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], (p. 475)[SP\_58\_mach], SP 53: Fusion Technology (p. 471)[SP\_53\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral exam: 30 minutes

**Conditions**material science  
solid mechanics II**Learning Outcomes**

The students know about the rules of established design codes for the assessment of components which under operation are subjected to high thermo-mechanical and/or irradiation loadings. They understand which constitutive equations are used according to state-of-the-art of technology and research to estimate deformation and damage appearing under these loadings and to predict expected lifetime. They gained insight into the application of these generally non-linear constitutive equations in finite element codes and can judge the major issues which shall be thereby taken into account.

**Content**

Contents of the lecture:

- rules of common design codes
- classical models for elasto-plasticity and creep
- lifetime rules for creep, fatigue and creep-fatigue interaction
- unified constitutive models for thermo-elasto-viscoplasticity
- continuum mechanical models for damage at high temperatures
- application of advanced material models in FE-codes

**Literature**

- R. Viswanathan, Damage Mechanisms and Life Assessment of High-Temperature Components, ASM International, 1989.
- Lemaitre, J.; Chaboche J.L.: Mechanics of Solid Materials, Cambridge University Press, Cambridge, 1990.

**Course: Design and Development of Mobile Machines [2113079]****Coordinators:** M. Geimer, J. Siebert**Part of the modules:** SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

homework in small groups during the semester + oral examination

**Conditions**

None.

**Recommendations**

Knowledge in Fluid Technology (SoSe, LV 21093)

**Learning Outcomes**

Students will learn:

1. How to develop a mobile working machine
2. How to apply existing knowledge on a specific problem
3. How to break down and structure a complex task
4. How knowledge of different courses can be brought together

**Content**

Wheel loaders and excavators are highly specialized mobile machines. Their function is to detach, pick up and deposit materials near by. Significant size for dimensioning of the machines is the content of their standard shovel. In this lecture the main steps in dimensioning a wheel loader or excavator are being thought. This includes among others:

- 
- Defining the size and dimensions,
- the dimensioning of the drive train,
- Determining the kinematics of the equipment,
- the dimension of the working hydraulics and
- Calculations of strength

The entire design process of these machines is strongly influenced by the use of standards and guidelines (ISO/DIN-EN). Even this aspect is dealt with.

The lecture is based on the knowledge from the fields of mechanics, strength of materials, machine elements, propulsion and fluid technique. The lecture requires active participation and continued collaboration.

**Literature**

None.

**Course: Dimensioning and Optimization of Power Train System [2146208]****Coordinators:** E. Kirchner**Part of the modules:** SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral Examination

**Conditions**

none

**Learning Outcomes**

The students gain the knowledge about ...

- functionality of conventional vehicle drive systems and design load for components.
- design- and functional principals of the main components of manual transmission, dual-clutch systems and automatic transmissions.
- comfort relevant interactions and corrective measures.
- requirements of hybridization and electrification of vehicles.
- evaluation on system level.

**Content**

1. Architectures: conventional, hybrid and electrical transmissions
2. The gear as system in a vehicle
3. Components and power flow of synchromesh gears
4. Spur gears
5. Synchronization
6. Switching systems for vehicles with manual transmission
7. Actuators
8. Comfort aspects for manual transmissions
9. Torque converter
10. Planetary sets
11. Power conversion in automatic transmissions
12. Continuously variable transmission systems
13. Differentials and components for power split
14. Drive train for commercial vehicles
15. Gears and electrical machines for electro mobility

## Course: Automated Manufacturing Systems [2150904]

**Coordinators:** J. Fleischer

**Part of the modules:** SP 44: Technical Logistics (p. 463)[SP\_44\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], (p. 475)[SP\_58\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 6              | Summer term | de                   |

### Learning Control / Examinations

The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None

### Recommendations

None

### Learning Outcomes

The students . . .

- are able to analyze implemented automated manufacturing systems and describe their components.
- are capable to assess the implemented examples of implemented automated manufacturing systems and apply them to new problems.
- are able to name automation tasks in manufacturing plants and name the components which are necessary for the implementation of each automation task.
- are capable with respect to a given task to plan the configuration of an automated manufacturing system and to determine the necessary components to its realization.
- are able to design and select components for a given use case of the categories: "Handling Technology", "Industrial Robotics", "Sensory" and "Controls".
- are capable to compare different concepts for multi-machine systems and select a suitable concept for a given use case.

### Content

The lecture provides an overview of the structure and functioning of automated manufacturing systems. In the introduction chapter the basic elements for the realization of automated manufacturing systems are given. This includes:

- Drive and control technology
- Handling technology for handling work pieces and tools
- Industrial Robotics
- Quality assurance in automated manufacturing
- automatic machines, cells, centers and systems for manufacturing and assembly
- structures of multi-machine systems
- planning of automated manufacturing systems

In the second part of the lecture, the basics are illustrated using implemented manufacturing processes for the production of automotive components (chassis and drive technology). The analysis of automated manufacturing systems for manufacturing of defined components is also included.

In the field of vehicle power train both, the automated manufacturing process for the production of the conventional internal-combustion engine and the automated manufacturing process for the production of the prospective electric power train (electric motor and battery) are considered. In the field of car body, the focus is on the analysis of the process chain for the automated manufacturing of conventional sheet metal body parts, as well as for automated manufacturing of body components made out of fiber-reinforced plastics.

Within tutorials, the contents from the lecture are advanced and applied to specific problems and tasks.

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

**Course: Automation Systems [2106005]****Coordinators:** M. Kaufmann**Part of the modules:** SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral, also possible as an optional or part of a major subject

**Conditions**

None.

**Recommendations**

Fundamentals of measuring and control engineering

**Learning Outcomes**

Students have fundamental knowledge about functionality, composition, components and development of industrial automation systems.

**Content**

- Introduction: Terms and definitions, examples, requirements
- Industrial processes: classification, process conditions
- Automation tasks
- Components of industrial automation systems: control functions, data acquisition, data output equipment, Programmable Logic Controllers, PC-based control
- Industrial communication, classification, topology, protocols, bus systems for automation systems
- Engineering: plant engineering, composition of control systems, programming
- Requirements on equipment, documentation, identification
- Dependability and safety
- Diagnosis
- Application examples

**Literature**

- Gevatter, H.-J., Grünhaupt, U.: Handbuch der Mess- und Regelungstechnik in der Produktion. 2. Auflage, Berlin, Heidelberg: Springer-Verlag, 2006.
- Langmann, R.: Taschenbuch der Automatisierung. München: Fachbuchverlag Leipzig, 2010.
- Strohrmann, G.: Automatisierung verfahrenstechnischer Prozesse: eine Einführung für Ingenieure und Techniker. München, Wien: Oldenbourg-Industrieverlag, 2002.
- Wellenreuther, G., Zastrow, D.: Automatisieren mit SPS: Theorie und Praxis. 4. Auflage, Wiesbaden: Vieweg+Teubner, 2009.

**Course: Automotive Engineering I [2113809]****Coordinators:** F. Gauterin, M. Gießler**Part of the modules:** (p. 475)[SP\_58\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term | en                   |

**Learning Control / Examinations**

Written examination

Duration: 120 minutes

Auxiliary means: none

**Conditions**

Examination in English

Can not be combined with lecture [2114835] Grundlagen der Fahrzeugtechnik I.

**Recommendations**

none

**Learning Outcomes**

The students know the movements and the forces at the vehicle and are familiar with active and passive security. They have proper knowledge about operation of engines and alternative drives, the necessary transmission between engine and drive wheels and the power distribution. They have an overview of the components necessary for the drive and have the basic knowledge, to analyze, to judge and to develop the complex system "vehicle".

**Content**

1. History and future of the automobile
2. Driving mechanics: driving resistances and driving performances, mechanics of the longitudinal and transverse forces, collision mechanics
3. Engines: combustion engine, alternative drives (e.g. electric motor, fuel cell)
4. Transmission: clutches (e.g. friction clutch, visco clutch), transmission (e.g. mechanical transmission, hydraulic fluid transmission)
5. Power transmission and distribution: drive shafts, cardon joints, differentials

**Literature**

1. Mitschke, M./ Wallentowitz, H.: Dynamik der Kraftfahrzeuge, Springer-Verlag, Berlin, 2004
2. Braes, H.-H.; Seiffert, U.: Handbuch Kraftfahrzeugtechnik, Vieweg&Sohn Verlag, 2005
3. Gnadler, R.: Script to the lecture 'Automotive Engineering I'

**Course: Automotive Engineering II [2114855]****Coordinators:** F. Gauterin, M. Gießler**Part of the modules:** SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

Written Examination

Duration: 90 minutes

Auxiliary means: none

**Conditions**

Examination in English

Can not be combined with lecture Grundlagen der Fahrzeugtechnik II.

**Recommendations**

none

**Learning Outcomes**

The students have an overview of the modules, which are necessary for the road holding of a motor vehicle and the power transmission between vehicle bodywork and roadway. They have knowledge of different wheel suspensions, the tyres, the steering elements and the brakes. They know different execution forms, the function and the influence on the driving or brake behavior. They are able to develop the appropriate components correctly. They are ready to analyze, to judge and to optimize the complex relationship of the different components under consideration of boundary conditions.

**Content**

1. Chassis: Wheel suspensions (rear axles, front axles, kinematics of axles), tyres, springs, damping devices
2. Steering elements: Steering elements of single vehicles and of trailers
3. Brakes: Disc brake, drum brake, retarder, comparison of the designs

**Literature**

1. Heißing, B./Ersoy, M.: Fahrwerkhandbuch: Grundlagen, Fahrdynamik, Komponenten, Systeme, Mechatronik, Perspektiven, Vieweg-Verlag, Wiesbaden, 2011
2. Breuer, B./Bill, K.-H.: Bremsenhandbuch: Grundlagen - Komponenten - Systeme - Fahrdynamik, Vieweg-Verlag, Wiesbaden, 2012
3. Gnadler, R.: Script to the lecture 'Automotive Engineering II'

**Course: Rail System Technology [2115919]****Coordinators:** P. Gratzfeld**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The students understand relations and interdependencies between rail vehicles, infrastructure and operation in a rail system.

They can assess the suitability of existing elements in the overall system.

They deduct the fundamental requirements for rail vehicles out of it.

**Content**

Introduction: railway as system, history, networks, traffic development, economic impact

Vehicle dynamics: driving resistance, tractive effort diagram, load cycles

Wheel-rail-contact: carrying of vehicle mass, adhesion, wheel guidance

Train protection: succession of trains, guideway

Traction power supply: power networks, power distribution, substations

Vehicles: definitions, compositions

Environmental aspect: energy consumption, traffic area, noise

**Media**

All slides are available for download (Ilias-platform).

**Literature**

A bibliography is available for download (Ilias-platform).

**Remarks**

none

**Course: Operation [6234801]****Coordinators:** E. Hohnacker**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

**Conditions**

See module description.

**Learning Outcomes**

See German version.

**Content**

Operation systems, signalling systems, operation schedule and timetable construction

**Literature****Elective literature:**

Fiedler: Grundlagen der Bahntechnik, Werner Verlag Düsseldorf

Pachl: Systemtechnik des Schienenverkehrs, Teubner-Verlag, Stuttgart

**Remarks**

See German version.

**Course: Fuels and Lubricants for Combustion Engines [2133108]****Coordinators:** B. Kehrwald**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], (p. 475)[SP\_58\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination, Duration: ca. 25 min., no auxiliary means

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students can name and explain composition and meaning of fuels, lubricants and coolants as important components in the system of today's Otto and Diesel engines as well as definition and chemical composition of fuels and lubricants, the meaning of crude oil as basic primary product, production processes, major properties, standards and specifications, testing methods.

They can point out future worldwide trends in the field of conventional and alternative fuels regarding emission standards and energy conservation

**Content**

Introduction and basics

Fuels for Gasoline and Diesel engines

Hydrogen

Lubricants for Gasoline and Diesel engines

Coolants for combustion engines

**Literature**

Lecturer notes

**Course: Operation Systems and Track Guided Infrastructure Capacity [6234804]****Coordinators:** E. Hohnecker**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

**Conditions**

See module description.

**Learning Outcomes**

See German version.

**Content**

Special signalling equipments, automatic driving, safety case, capacity of railway equipments, dimensioning of marshaling yards.

**Literature****Elective literature:**

Fiedler: Grundlagen der Bahntechnik, Werner Verlag Düsseldorf

Pachl: Systemtechnik des Schienenverkehrs, Teubner-Verlag, Stuttgart

**Remarks**

See German version.

**Course: Evaluation of welded joints [2181730]****Coordinators:** P. Gumbsch, M. Farajian, Farajian, Majid**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Exercise sheets are handed out regularly.  
oral examination (30 min)

no tools or reference materials

**Conditions**

None.

**Recommendations**

preliminary knowlegde materials science and mechanics

**Learning Outcomes**

The student can

- describe the influence of welding induced notches, defects and residual stresses on component behavior
- explain the basics of numerical and experimental methods for the evaluation of statically or cyclically loaded welds explain and can apply them
- derive measures in order to increase the lifetime of structures with welded joints under cyclical load

**Content**

The lecture gives an introduction to the following topics:

- weld quality
- typical damages of welded joints
- evaluation of notches, defects and residual stresses
- strength concepts: nominal, structural and notch stress concepts, fracture mechanics
- life cycle analysis
- post-treatment methods for an extented lifetime
- maintenance, reconditioning and repair

**Media**

Black board and slides (beamer).

**Literature**

1. D. Radaj, C.M. Sonsino and W. Fricke, Fatigue assessment of welded joints by local approaches, Second edition. Woodhead Publishing, Cambridge 2006.
2. FKM-Richtlinie, Bruchmechanischer Festigkeitsnachweis, Forschungskuratorium Maschinenbau, VDMA Verlag, 2009

**Course: Medical Imaging Techniques I [23261]****Coordinators:** O. Dössel**Part of the modules:** SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Written Exam

**Conditions**

None.

**Recommendations**

23275

**Learning Outcomes**

Comprehensive understanding of all methods of medical imaging based on ionizing radiation

This course teaches students to understand theoretical aspects and engineering of x-ray imaging systems (incl. Computed Tomography) and imaging methods of Nuclear Medicine (SPECT and PET).

**Content**

X-ray Physics and technique of X-ray imaging

Digital radiography, x-ray image intensifier, flat x-ray detectors

Theory of imaging systems, Modulation-Transfer-Function and Detective Quantum Efficiency

Computer Tomography CT

Ionizing radiation, dosimetry and radiation protection

SPECT and PET

**Literature**

Bildgebende Verfahren in der Medizin, Olaf Dössel, Springer Verlag

**Remarks**Current information can be found on the ITIV (<http://www.ibt.kit.edu/>) webpage and within the eStudium-teachingplatform ([www.estudium.org](http://www.estudium.org)).

**Course: Medical Imaging Techniques II [23262]****Coordinators:** O. Dössel, O. Dössel**Part of the modules:** SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of a written exam (approx. 120 minutes) according to sec. 4 subsec. 2 no. 1 study and examination regulations.

**Conditions**

None.

**Learning Outcomes****Content**

**Course: Bioelectric Signals [23264]****Coordinators:** G. Seemann, G. Seemann**Part of the modules:** SP 32: Medical Technology (p. [448](#))[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (approx. 20 minutes) according to sec. 4 subsec. 2 no. 2 study and examination regulations.

**Conditions**

None.

**Learning Outcomes****Content**

**Course: Biomedical Measurement Techniques I [23269]****Coordinators:** W. Stork, A. Bolz**Part of the modules:** SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (approx. 20 minutes) according to sec. 4 subsec. 2 no. 2 study and examination regulations.

**Conditions**

None.

**Learning Outcomes****Content**

**Course: Biomedical Measurement Techniques II [23270]****Coordinators:** W. Stork, A. Bolz**Part of the modules:** SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (approx. 20 minutes) according to sec. 4 subsec. 2 no. 2 study and examination regulations.

**Conditions**

None.

**Learning Outcomes****Content**

## Course: BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I [2141864]

**Coordinators:** A. Guber

**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral examination: Elective Course (Duration: 30 minutes) or Main Course in combination with other lectures (Duration: 60 minutes)

Aids: none

### Conditions

None.

### Learning Outcomes

The lecture will first address relevant microtechnical manufacturing methods. Then, selected biomedical applications will be presented, as the increasing use of microstructures and microsystems in Life-Sciences and in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

### Content

Introduction into various microtechnical manufacturing methods: LIGA, Micro milling, Silicon Micromachining, Laser Microstructuring,  $\mu$ EDM, Metal-Etching

Biomaterials, Sterilisation.

Examples of use in the life science sector: basic micro fluidic structures: micro channels, micro filters, micromixers, micropumps, microvalves, Micro and nanotiter plates, Microanalysis systems ( $\mu$ TAS), Lab-on-chip applications.

### Media

Lecture script

### Literature

Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005

M. Madou

Fundamentals of Microfabrication

Taylor & Francis Ltd.; Auflage: 3. Auflage. 2011

## Course: BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II [2142883]

**Coordinators:** A. Guber

**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral: Elective Course (Duration: 30 minutes) or Main Course in combination with other lectures (Duration: 60 minutes)

Aids: none

### Conditions

None.

### Learning Outcomes

The lecture will first shortly address some relevant microtechnical manufacturing methods. Then, selected biomedical applications will be presented, as the increasing use of microstructures and microsystems in Life-Sciences und in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

### Content

Examples of use in Life-Sciences and biomedicine: Microfluidic Systems:

LabCD, Protein Crystallisation

Microarrays

Tissue Engineering

Cell Chip Systems

Drug Delivery Systems

Micro reaction technology

Microfluidic Cells for FTIR-Spectroscopy

Microsystem Technology for Anesthesia, Intensive Care and Infusion

Analysis Systems of Person's Breath

Neurobionics and Neuroprosthesis

Nano Surgery

### Media

Lecture script

### Literature

Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005

Buess, G.: Operationslehre in der endoskopischen Chirurgie, Band I und II;

Springer-Verlag, 1994

M. Madou

Fundamentals of Microfabrication

## Course: BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III [2142879]

**Coordinators:** A. Guber

**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral: Elective Course (Duration: 30 minutes) or Main Course in combination with other lectures (Duration: 60 minutes)

Aids: None

### Conditions

None.

### Learning Outcomes

The lecture will first shortly address some relevant microtechnical manufacturing methods. Then, selected biomedical applications will be presented, as the increasing use of microstructures and microsystems in Life-Sciences und in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

### Content

Examples of use in minimally invasive therapy  
 Minimally invasive surgery (MIS)  
 Endoscopic neurosurgery  
 Interventional cardiology  
 NOTES  
 OP-robots and Endosystems  
 License of Medical Products and Quality Management

### Media

Lecture script

### Literature

Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005  
 Buess, G.: Operationslehre in der endoskopischen Chirurgie, Band I und II;  
 Springer-Verlag, 1994  
 M. Madou  
 Fundamentals of Microfabrication

**Course: Bionics for Engineers and Natural Scientists [2142140]****Coordinators:** H. Hölscher**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The successful attendance of the lecture is controlled by a 30 minutes written examination, and a subsequent oral examination (20 min). Passing the written exam is mandatory for the participation of the oral examination. The grade result is the result of the oral exam.

**Conditions**

none

**Recommendations**

Basic knowledge in physics and chemistry

**Learning Outcomes**

The students should be able analyze, judge, plan and develop biomimetic strategies and products.

**Content**

Bionics focuses on the design of technical products following the example of nature. For this purpose we have to learn from nature and to understand its basic design rules. Therefore, the lecture focuses on the analysis of the fascinating effects used by many plants and animals. Possible implementations into technical products are discussed in the end.

**Media**

Slides of the lectures

**Literature**

Werner Nachtigall: Bionik – Grundlagen und Beispiele für Ingenieure und Naturwissenschaftler. Springer-Verlag Berlin (2002), 2. Aufl.

**Course: BUS-Controls [2114092]****Coordinators:** M. Geimer**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (20 min) taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

**Conditions**

Basic knowledge of electrical engineering is recommended. Programming skills are also helpful.

**Learning Outcomes**

The students will get an overview of the theoretic and practical functioning of different bus systems.

After the practical oriented lessons the students will be able to visualize the communication structure of different applications, design basic systems and evaluate the complexity of programming of the complete system.

**Content**

- Knowledge of the basics of data communication in networks
- Overview of the operating mode of current field buses
- Explicit observation of the operating mode and application areas of CAN buses
- Practical programming of an example application (hardware is provided)

**Literature****Elective literature:**

- Etschberger, K.: Controller Area Network, Grundlagen, Protokolle, Bausteine, Anwendungen; München, Wien: Carl Hanser Verlag, 2002.
- Engels, H.: CAN-Bus - CAN-Bus-Technik einfach, anschaulich und praxisnah dargestellt; Poing: Franzis Verlag, 2002.

**Remarks**

The course will be replenished by interesting lectures of professionals.

**Course: CATIA CAD training course [2123358]****Coordinators:** J. Ovtcharova**Part of the modules:** SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 2            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Practical examination, duration: 60 min., auxiliary means: script

**Conditions**

None

**Recommendations**

Dealing with technical drawings is required.

**Learning Outcomes**

Students are able to:

- create their own 3D geometric models in the CAD system CATIA and generate drawings due to the created geometry
- carry out FE-studies and kinematic simulations using the integrated CAE tools
- use advanced, knowledge-based functionalities of CATIA to automate the creation of geometry and thus to ensure the reusability of the models.

**Content**

The participant will learn the following knowledge:

- Basics of CATIA such as user interface, handling etc.
- Production and processing of different model types
- Production of basic geometries and parts
- Generation of detailed drawings
- Integration of partial solutions in modules
- Working with constrains
- Strength analysis with FEM
- Kinematic simulation with DMU
- Dealing with CATIA Knowledgeware

**Literature**

practical course skript

**Remarks**

For the practical course attendance is compulsory.

**Course: CAD-NX training course [2123357]****Coordinators:** J. Ovtcharova**Part of the modules:** SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 2            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Practical examination, duration: 60 min., auxiliary means: script

**Conditions**

None

**Recommendations**

Dealing with technical drawings is required.

**Learning Outcomes**

Students are able to:

- create their own 3D geometric models in the CAD system NX and generate drawings due to the created geometry
- carry out FE-studies and kinematic simulations using the integrated CAE tools
- use advanced, knowledge-based functionalities of NX to automate the creation of geometry and thus to ensure the reusability of the models.

**Content**

The participant will learn the following knowledge:

- Overview of the functional range
- Introduction to the work environment of NX
- Basics of 3D-CAD modelling
- Feature-based modelling
- Freeform modelling
- Generation of technical drawings
- Assembly modelling
- Finite element method (FEM) and multi-body simulation (MBS) with NX

**Literature**

Practical course skript

**Remarks**

For the practical course compulsory attendance exists.

**Course: CAE-Workshop [2147175]****Coordinators:** A. Albers, Assistenten**Part of the modules:** SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 3              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Depending on the manner in which the CAE-Workshop will be credited.

**Conditions**

compulsory attendance

**Recommendations**

We suggest this Workshop after 2 years of classes.

**Learning Outcomes**

The students are able to ...

- name the purposes and limits of numerical simulation and optimization of the virtual product development.
- solve simple realistic tasks in the field of finite element analysis, multi-body-simulation and structure optimization with industrial common software (the content in winter and summer term is different).
- evaluate and to question the results of a simulation.
- identify and improve the mistakes of a simulation or optimization.

**Content**

Content in the summer semester:

- introduction to the finite element analysis (FEA)
- stress and modal analysis of finite element models using Abaqus/CAE as a preprocessor and Abaqus solver
- introduction to topology and shape optimization
- creation and calculation of various optimization models with the optimization package TOSCA and the Abaqus solver

Content in the winter semester:

- introduction to the finite element analysis (FEA)
- stress and modal analysis of finite element models using Abaqus/CAE as a preprocessor and Abaqus solver
- introduction to multi-body simulation (MBS)
- preparation and running of multi-body simulation models. Coupling of the MBS and FEA to calculate hybrid multi-body simulation problems.

**Literature**

The workshop script will be allocated at Ilias.

**Course: CATIA advanced [2123380]****Coordinators:** J. Ovtcharova**Part of the modules:** SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Presentation of the results at the end of semester and oral examination, duration: 10 min.

**Conditions**

None

**Recommendations**

Very good knowledge of Machine Design and an excellently passed CAD practical course CATIA at the IMI are required.

**Learning Outcomes**

At the workshop, a complete CAD model of a transmission is developed.

The design problem is worked out in small groups. Using a basic sketch the participants have to design partial solutions independently, test and then integrate them into the overall solution. The advanced capabilities of CATIA are dealt with. The design process should be simulated from idea to finished model.

The focus is on independent solution finding, teamwork, functional performance, production and design.

**Content**

- Use of advanced CAD techniques and CATIA functionalities
- Management of data using the PLM system SmarTeam
- Design engineering with CAD
- Integration of partial solutions into the overall solution
- Ensuring the reusability of CAD models through parameterization and cataloging
- Validation, strength tests (FEM analysis)
- Kinematic simulation with the digital mockup (DMU Kinematics)
- Production with integrated CAM tool
- Animations
- Presentation of results at the end of the semester

**Remarks**

For the workshop compulsory attendance exists.

**Course: CFD for Power Engineering [2130910]****Coordinators:** I. Otic**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 53: Fusion Technology (p. 471)[SP\_53\_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

Oral exam, length: 30 minutes

**Conditions**

None.

**Learning Outcomes**

After completing the course students are able:

- to understand the fundamentals of computational fluid dynamics (CFD)
- to simulate turbulent flow with heat transfer using CFD
- to present, analyse and evaluate the simulation results.

**Content**

This course is specified for both Bachelor and Master students, Power and Nuclear Engineering.

The course is aimed of giving the fundamental of Computational Fluid Dynamics (CFD) for energy technologies. Starting from the basic physical phenomena equations an overview on computational methods and turbulence modeling is given.

## Course: CFD-Lab using Open Foam [2169459]

**Coordinators:** R. Koch

**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

### Learning Control / Examinations

- Successful solution of problems

### Conditions

- Fluid Dynamics
- Course on numerical fluid mechanics

### Recommendations

- Basic knowledge in LINUX

### Learning Outcomes

The students are able to:

- use OpenFOAM
- generate simple grids or import grids into OpenFOAM
- choose and define appropriate boundary conditions
- estimate numerical errors and assess them
- judge turbulence models and select an appropriate model
- simulate 2-phase flows using suitable models

### Content

- Introduction to using Open Foam
- Grid generation
- Boundary conditions
- Numerical errors
- Discretization schemes
- Turbulence models
- Two phase flow - spray
- Two Phase flow - Volume of Fluid method

### Media

- A CD containing the course material will be handed out to the students

### Literature

- Documentation of Open Foam
- [www.openfoam.com/docs](http://www.openfoam.com/docs)

**Remarks**

- Number of participants is limited
- Priority for students of the lecture “Numerische Simulation reagierender Zweiphasenströmungen” (Vorl.-Nr. 2169458)

**Course: Computational Intelligence I [2106004]****Coordinators:** G. Bretthauer, R. Mikut**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination (1 hour)

Duration: 1 hours, also possible as an optional or part of a major subject

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students are able to apply the methods of fuzzy logic and fuzzy control efficiently. They know the basic mathematical foundations for the model design using fuzzy logic (membership functions, inference methods, defuzzification). In addition, they are able to design fuzzy controllers (Mamdani controllers and hybrid controllers with fuzzy-adaptive components) for practical applications.

**Content**

Terms and definitions Computational Intelligence, application fields and examples

Fuzzy logic and fuzzy sets

Fuzzification and membership functions

Inference: T-norms and -conorms, operators, aggregation, activation, accumulation

Defuzzification methods

Structures for fuzzy control

Software practice (fuzzyTECH) and applications (crane control)

**Literature**

Kienzl, H.: Fuzzy Control. Methodenorientiert. Oldenbourg-Verlag, München, 1997

Bandemer, H.; Gottwald, S.: Einführung in Fuzzy Methoden. Akademie-Verlag, Berlin, 1993

Zadeh, L.A.: Fuzzy Sets. Information and Control, 8, 338-353, 1965

Mikut, R.: Data Mining in der Medizin und Medizintechnik. Universitätsverlag Karlsruhe, Kapitel 5.5; 2008 (Internet)

Software: FuzzyTech (für die Übung)

**Course: Computational Intelligence II [2105015]****Coordinators:** G. Bretthauer, R. Mikut**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination (1 hour)

Duration: 1 hours, also possible as an optional or part of a major subject

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students are able to apply the methods of Artificial Neural Networks and Evolutionary Algorithms efficiently. They know the basic mathematical foundations and the goal-oriented design and the problem formulation for technical applications (selection of net structures for Artificial Neural Networks, optimization using Evolutionary Algorithms with coding of potential solutions for real-world applications as individuals).

**Content**

Terms and definitions, application fields and examples

Biological foundations of neural nets

Artificial Neural Nets: neurons, Multi-Layer-Perceptrons, Radial-Basis-Function nets, Kohonen maps, training strategies (Backpropagation, Levenberg-Marquardt)

Evolutionary Algorithms: Genetic Algorithms and Evolution Strategies, mutation, recombination, evaluation, selection, integration of local search strategies

Software practice (Gait-CAD, GLEAMKIT) and applications

**Literature**

S. Haykin: Neural Networks: A Comprehensive Foundation. Prentice Hall, 1999

T. Kohonen: Self-Organizing Maps. Berlin: Springer-Verlag, 1995

R. Rojas: Theorie der Neuronalen Netze. Berlin: Springer-Verlag, 1995

W. Jakob: Eine neue Methodik zur Erhöhung der Leistungsfähigkeit Evolutionärer Algorithmen durch die Integration lokaler Suchverfahren. Forschungszentrum Karlsruhe, 2004

H.-P. Schwefel: Evolution and Optimum Seeking. New York: John Wiley, 1995

H.J. Holland: Adaptation in Natural and Artificial Systems. Ann Arbor, 1975

R. Mikut: Data Mining in der Medizin und Medizintechnik. Universitätsverlag Karlsruhe, 2008 (Internet, Kapitel 5.6)

**Course: Computational Intelligence III [2106020]****Coordinators:** R. Mikut**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination (1 hour)

Duration: 1 hours, also possible as an optional or part of a major subject

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students are able to apply the methods of data analysis efficiently. They know the basic mathematical foundations for the analysis of single features and time series using classifiers, clustering and regression approaches. They are able to use various relevant methods as Bayes classifiers, Support Vector Machines, decision trees, fuzzy rulebases and they can adapt application scenarios (with data preprocessing and validation techniques) to real-world applications.

**Content**

Introduction and motivation

Terms and definitions (types of multidimensional features - time series and images, problem classes)

Application scenario: Problem formulation, feature extraction, evaluation, selection and transformation, distance measures, Bayes classifiers, Support-Vector-Machines, decision trees, clustering, regression, validation

Application (Software practice with Gait-CAD): Control of hand prostheses, energy prediction

**Literature**

Lecture notes (Internet)

Mikut, R.: Data Mining in der Medizin und Medizintechnik. Universitätsverlag Karlsruhe. 2008 (Internet)

Backhaus, K.; Erichson, B.; Plinke, W.; Weiber, R.: Multivariate Analysemethoden: Eine anwendungsorientierte Einführung. Berlin u.a.: Springer. 2000

Burges, C.: A Tutorial on Support Vector Machines for Pattern Recognition. Knowledge Discovery and Data Mining 2(2) (1998), S. 121–167

Tatsuoka, M. M.: Multivariate Analysis. Macmillan. 1988

Mikut, R.; Loose, T.; Burmeister, O.; Braun, S.; Reischl, M.: Dokumentation der MATLAB-Toolbox Gait-CAD. Techn. Ber., Forschungszentrum Karlsruhe GmbH. 2006 (Internet)

**Course: Railways in the Transportation Market [2114914]****Coordinators:** P. Gratzfeld**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The students learn about the entrepreneurial approach and viewpoint of railways. They comprehend key issues of the transport policy, regulatory as well as financial framework, and grasp strategic fields of action in international as well as intermodal market perspectives.

**Content**

The lecture gives an overview about perspective, challenges and chances of rail systems in the national and European market. Following items will be discussed:

- Introduction and basics
- Rail reform
- Overview of Deutsche Bahn
- Development of infrastructure
- Regulation of railways
- Intra- and intermodal competition
- Field of actions in transport policy
- Railways and environment
- Trends in the transportation market
- Future of Deutsche Bahn, DB 2020
- Integration of traffic carriers
- International passenger and freight transportation

**Media**

All material is available for download (Ilias-platform).

**Literature**

none

**Remarks**

For the dates please see special announcement on the website [www.bahnsystemtechnik.de](http://www.bahnsystemtechnik.de)

## Course: Finite Difference Methods for numerical solution of thermal and fluid dynamical problems [2153405]

**Coordinators:** C. Günther

**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral

Duration: 30 minutes

no auxiliary means

### Conditions

None.

### Learning Outcomes

The students can apply the most important difference schemes for the numerical solution of steady and transient problems which are typical for thermal and fluid flow problems. They are able to discuss the most relevant properties of difference schemes such as consistency, stability and convergence. Furthermore, they can estimate the order of the numerical error and non-appearance of numerical oscillations.

### Content

The lecture initially presents an overview and then the most important difference schemes for the numerical solution of steady and transient problems which are typical for thermal and fluid flow problems. The most relevant properties of difference schemes at one side as consistency, stability and convergence, at the other side the order of the numerical error and non-appearance of numerical oscillations are described. Algorithms for the solution of coupled systems of equations, characteristic for fluid flow and thermal problems, are reviewed.

- Spatial and temporal discretization
- Properties of difference schemes
- Numerical stability, consistency, convergence
- Nonhomogeneous meshes
- Coupled and noninteracting calculation methods

**Course: Digital Control [2137309]****Coordinators:** M. Knoop**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination; duration: 30 minutes; no tools or reference materials may be used during the exam.

**Conditions**

Basic studies and preliminary examination; basic lectures in automatic control

**Learning Outcomes**

The lecture introduces key methods for the analysis and design of digital feedback control systems. Starting point is the discretisation of linear, continuous-time models. State space based and z-transform based controller design techniques are presented for discrete-time, single-input single-output systems. Furthermore, plants with dead-time and deadbeat design are covered.

**Content**

1. Introduction into digital control:

Motivation for digital implementation of controllers Structure of digital feedback control loops Sample and hold units

2. State space analysis and design:

Discretisation of continuous-time systems Discrete-time state space equations Stability - definition and criteria State feedback design by eigenvalue assignment PI state feedback controller Luenberger observer, separation theorem Systems with dead-time Deadbeat design

3. Analysis and design based on z-transform: z-transform - definition and theorems Control loop description in the z domain

Stability criteria Root locus controller design Transfer of continuous-time controllers into discrete-time controllers

**Literature**

- Lunze, J.: Regelungstechnik 2, 3. Auflage, Springer Verlag, Berlin Heidelberg 2005
- Unbehauen, H.: Regelungstechnik, Band 2: Zustandsregelungen, digitale und nichtlineare Regelsysteme. 8. Auflage, Vieweg Verlag, Braunschweig 2000
- Föllinger, O.: Lineare Abtastsysteme. 4. Auflage, R. Oldenbourg Verlag, München Wien 1990
- Ogata, K.: Discrete-Time Control Systems. 2nd edition, Prentice-Hall, Englewood Cliffs 1994
- Ackermann, J.: Abtastregelung, Band I, Analyse und Synthese. 3. Auflage, Springer Verlag, Berlin Heidelberg 1988

**Course: Designing with numerical methods in product development [2161229]****Coordinators:** E. Schnack**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination. Duration: 30 minutes.

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students are provided with a detailed overview of the numerical methods for product development in mechanical engineering. Account is taken of the fact that a modern development of products in mechanical engineering generally involves a multi-field approach: knowledge of thermodynamics, fluid mechanics, solid mechanics, electronics / electrics and magnetism are required. In addition, problems can be steady but are very often unsteady, i.e. time-dependent. All these aspects are incorporated into modern industrial software. In the lectures the fundamental methods used in the development of the software are introduced and discussed in detail. Students are provided with the tools to carry out the design process on a computer using existing industrial software. It is also worth noting that beside the finite element and the boundary element methods, structural optimisation with shape and topological optimisation must be taken into account. Structural optimisation will play an increasingly important role in the future.

**Content**

Overview of the numeric process: finite difference methods, finite volume methods. Finite element methods. Boundary element method (BEM). Thermodynamic processes. Flow dynamic processes. Solid dynamics. Non-linear field behaviour. These methods are summarised at the end of the course, and a holistic concept for design processes is developed.

**Literature**

Lecture notes (available in the administration office, building 10.91, rm. 310)

**Course: Designing with composites [2162255]****Coordinators:** E. Schnack**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination. Duration: 30 minutes.

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The aim is to gain understanding of laminated composite materials with a wide variety of applications in the aerospace and automotive industries. The terminology used for modern composites will be introduced and the students will gain an understanding of lamina, laminae and laminate. In addition they will gain understanding of the transformation properties between a single-layer and a multi-layer coordinate system. They will understand new aspects of composites such as the piezo-electric monitoring of composite materials.

**Content**

Short overview of the definition of modern composite materials. Fundamental structure of industrial composites. Definition of the mixture rules for fibre and matrix materials. Calculation of a wide variety of transformations between lamina, laminae and laminate for different coordinate systems. Derivation of the relevant differential equations for composites.

**Literature**

Lecture notes available in the administration office, building 10.91, rm. 310

**Course: Dynamics of mechanical Systems with tribological Contacts [2162207]****Coordinators:** H. Hetzler**Part of the modules:** SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral exam., 30min

**Conditions**

None.

**Learning Outcomes**

This lecture gives an introduction in to basic aspects of mechanical systems with contacts. Here, the tribological contact properties must be respected as well, since it affects the contact behaviour.

The course begins with the physical-mathematical description and addresses common solution strategies. By several example problems typical dynamic phenomena are discussed.

**Content**

- \* Introduction into contact kinematics
- \* kinetics of mechanical systems with frictional unilateral contacts
- \* mathematical solution strategies
- \* introduction into contact mechanics
- \* normal contact (Hertzian contact, rough surfaces, constitutive contact laws)
- \* impacts (Newton's Impact law, wave effects)
- \* friction induced vibrations (stick-slip, squeal, ...)
- \* lubricated contacts: Reynold's Equation, rotors in fluid film bearings, EHD-contacts

**Literature**

list of literature will be handed out

**Course: Dynamics of the Automotive Drive Train [2163111]****Coordinators:** A. Fidlin**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 4              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 min (optional subject)

20 min (major subject)

Means are not allowed

**Conditions**

None.

**Recommendations**

Powertrain Systems Technology A: Automotive Systems

Machine Dynamics

Vibration theory

**Learning Outcomes**

- To obtain the basic skills in dynamic modelling of the vehicle powertrain including the most important components, driving situations and requirements

**Content**

- Main components of the vehicle powertrain and their modelling
- Typical driving situations
- Problem-oriented models for particular driving situations
- System analysis and optimization with respect to dynamic behavior

**Literature**

- Dresig H. Schwingungen mechanischer Antriebssysteme, 2. Auflage, Springer, 2006
- Pfeiffer F., Mechanical System Dynamics, Springer, 2008
- Laschet A., Simulation von Antriebssystemen: Modellbildung der Schwingungssysteme und Beispiele aus der Antriebstechnik, Springer, 1988

**Course: Introduction to the Finite Element Method [2162282]****Coordinators:** T. Böhlke**Part of the modules:** SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 4              | Summer term | de                   |

**Learning Control / Examinations**

depending on choice according to actual version of study regulations

Additives as announced

Prerequisites are met by attestations during the associated lab course.

**Conditions**

The institute decides about registration for the lab course (restricted number of participants).

**Recommendations**

None.

**Learning Outcomes**

The students can

- apply the most important tensorial operations in the framework of linear elasticity
- analyse the initial-boundary-value problem of linear thermal conductivity
- analyse the boundary-value problem of linear elasticity
- assess the spatial discretization for 3D problems
- derive the weak form for solving a boundary value problem
- evaluate solution methods for linear systems of equations
- choose an appropriate element-type for performing a finite-element-analysis for a given problem
- evaluate error estimations for the results of a finite-element-analysis
- autonomously perform a finite-element-analysis using the software ABAQUS

**Content**

- introduction and motivation
- elements of tensor calculus
- the initial-boundary-value-problem of linear thermoconductivity
- the boundary-value-problem of linear elastostatic
- spatial discretization for 3D problems
- solution of the boundary-value-problem of elastostatic
- numerical solution of linear systems
- element types
- error estimation

**Literature**

lecture notes

Fish, J., Belytschko, T.: A First Course in Finite Elements, Wiley 2007 (includes an introduction into ABAQUS)

**Course: Introduction to Nuclear Energy [2189903]****Coordinators:** X. Cheng**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content**

**Course: Introduction to Nuclear Engineering [2130974]****Coordinators:** X. Cheng**Part of the modules:** SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination; duration: 20 minutes

**Conditions**

None.

**Learning Outcomes**

This lecture is dedicated to students of mechanical engineering and other engineering bachelor or master degree courses. Goal of this lecture is it to get fundamental understanding of major aspects in nuclear engineering and nuclear energy.

**Content**

1. Fission and energy production
2. fundamentals in reactor physics
3. classification and design of nuclear facilities
4. nuclear materials
5. reactor safety
6. radiation protection
7. fuel cycle
8. economical aspects
9. development tendencies in nuclear engineering

**Course: Introduction to Theory of Materials [2182732]****Coordinators:** M. Kamlah**Part of the modules:** SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 30: Applied Mechanics (p. 445)[SP\_30\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral exam 30 minutes

**Conditions**

Engineering Mechanics; Advanced Mathematics

**Learning Outcomes**

The student can judge for a problem to be computed, which constitutive model should be selected depending on choice of material and loading. For computation tools such as commercial finite element codes, the students can understand the documentation with respect to the implemented constitutive models, and they can make their choice based on their knowledge. The students have basic knowledge for the development of constitutive laws.

**Content**

Following a brief introduction into continuum mechanics at small deformations, the classification into elastic, viscoelastic, plastic and viscoplastic constitutive models of solids is discussed. Then, one after the other, the four groups of elastic, viscoelastic, plastic and viscoplastic constitutive models are motivated and mathematically formulated. Their properties are demonstrated by means of elementary analytical solutions and examples.

**Literature**

- [1] Peter Haupt: Continuum Mechanics and Theory of Materials, Springer
- [2] Lecture Notes

## Course: Introduction to the Mechanics of Composite Materials [2178734]

**Coordinators:** Y. Yang

**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

### Conditions

Solid Mechanics

### Learning Outcomes

The students understand the fundamentals of the mechanical properties of composite materials. Based on this they can apply design rules for composite materials. They are able to analyze lightweight structures with respect to their mechanical properties.

### Content

- Introduction to composite materials, applied examples in the industry
- Micromechanical behaviour of a lamina
- Macromechanical behaviour of a lamina
- Macromechanical behaviour of a laminate (I): classical lamination theory
- Macromechanical behaviour of a laminate (II): stiffness / stress analysis
- Strength of laminates, failure criteria in laminates
- Optimization and Design of fiber reinforced composite materials

### Literature

[1] Robert M. Jones (1999), Mechanics of Composite Materials

[2] Valery V. Vasiliev & Evgeny V. Morozov (2001), Mechanics and Analysis of Composite Materials, ISBN: 0-08-042702-2

[3] Helmut Schürmann (2007), Konstruieren mit Faser-Kunststoffverbunden, Springer, ISBN: 978-3-540-72189-5 .

**Course: Introduction into Mechatronics [2105011]****Coordinators:** G. Bretthauer, A. Albers**Part of the modules:** SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 50: Rail System Technology (p. 469)[SP\_50\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | de                   |

**Learning Control / Examinations**

Written examination, oral examination or certification of participation depending on the "Studienplan" resp. "Prüfungs- und Studienordnung (SPO)".

**Conditions**

none

**Learning Outcomes**

The student has knowledge about the specific challenge of interdisciplinary collaboration within the framework of mechatronics. He is able to explain the origin, necessity and methodic implementation of interdisciplinary collaboration, to name the main difficulties as well as the special features within the development of mechatronic products from the point of view of development methodic.

The student has fundamental knowledge of modeling mechanical, hydraulically and electrically part systems and about suitable optimization methods.

The student knows the difference in use of the term "system" in mechatronic and mechanical use.

**Content****Part I: Modeling and optimization** (Prof. Bretthauer)

Introduction

Architecture of mechatronic systems

Modeling of mechatronic systems

Optimization of mechatronic systems

Perspective

**Part II: Development and design** (Prof. Albers)

Introduction

Development method for mechatronic products

Examples

**Literature**

Heimann, B.; Gerth, W.; Popp, K.: Mechatronik. Leipzig: Hanser, 1998

Isermann, R.: Mechatronische Systeme - Grundlagen. Berlin: Springer, 1999

Roddeck, W.: Einführung in die Mechatronik. Stuttgart: B. G. Teubner, 1997

Töpfer, H.; Kriesel, W.: Funktionseinheiten der Automatisierungstechnik. Berlin: Verlag Technik, 1988

Föllinger, O.: Regelungstechnik. Einführung in die Methoden und ihre Anwendung. Heidelberg: Hüthig, 1994

Bretthauer, G.: Modellierung dynamischer Systeme. Vorlesungsskript. Freiberg: TU Bergakademie, 1997

**Course: Introduction into the multi-body dynamics [2162235]****Coordinators:** W. Seemann**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Written or oral exam.

Announcement 6 weeks prior to examination date.

**Conditions**

None.

**Learning Outcomes**

The students know different possibilities to describe the position und orientation of rigid bodies. They realize that during numerical integration of the kinematic differential equations singularities may arise which may be avoided if for examle Euler-parameters are used. Holonomic as well as nonholonomic constraints and their effect on the structure of the differential equations are known. The description of the kinematic quantities in different reference systems can be done. The formulation of the moment of momentum using different reference frames for rotational velocity and inertia tensor is not a problem. Several methods for the derivation of equations of motion can be applied, especially for nonholonomic systems. The solution of equations of motion by numerical integration is understood in principle.

**Content**

The role of multibody systems in engineering, kinematics of a single rigid body, Kinematics of multibody systems, rotation matrix, angular velocity, derivatives in different reference systems, holonomic and non-holonomic constraints, Newton-Euler's equations, principle of d'Alembert, principle of virtuel power, Lagrange's equations, Kane's equations, structure of the equations of motion

**Literature**

Wittenburg, J.: Dynamics of Systems of Rigid Bodies, Teubner Verlag, 1977

Roberson, R. E., Schwertassek, R.: Dynamics of Multibody Systems, Springer-Verlag, 1988

de Jal'on, J. G., Bayo, E.: Kinematik and Dynamic Simulation of Multibody System.

Kane, T.: Dynamics of rigid bodies.

**Course: Introduction to modeling of aerospace systems [2154430]****Coordinators:** G. Schlöffel**Part of the modules:** SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min

no auxiliary means

**Conditions**

none

**Recommendations**

basic skills in mathematics, physics and fluid dynamics

**Learning Outcomes**

Students attending this lecture will be able to,

- give an outline of the common methods of modeling the flight of aerospace systems,
- describe the different phases of flight of an aerospace system launching from earth,
- handle and compute the physics and its particular impact on the aerospace system during the different phases of flight,
- discriminate and treat in particular the effects of gravitation, propulsion and aerodynamics,
- characterize and describe possible flight paths and orbits,
- implement in Matlab/Simulink the fundamental equations of motion with respect to the simulation of an aerospace system

**Content**

This lecture covers the following topics:

- Reference and coordinate systems and their transformations
- Newton-Euler-Equations of motion
- Gravitation
- Propulsion of aerospace systems
- Aerodynamics
- Trajectories and Orbits
- Re-entry
- Implementation of a Matlab/Simulink simulation

**Literature**

- P. H. Zipfel: Modeling and Simulation of Aerospace Vehicle Dynamics. American Institute of Aeronautics and Astronautics (AIAA), Reston 2007. ISBN 978-1563478758
- A. Tewari: Atmospheric and Space Flight Dynamics. Birkhäuser, Boston 2007. ISBN 978-0-8176-4373-7
- W. Ley, K. Wittmann, W. Hallmann (Hrsg.): Handbuch der Raumfahrttechnik. Hanser, München 2011. ISBN 978-3446424067
- W. Büdeler: Geschichte der Raumfahrt. Edition Helmut Sigloch, Künzelsau 1999. ISBN 978-3893931941

**Course: Introduction to numerical mechanics [2161226]****Coordinators:** E. Schnack**Part of the modules:** SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination. Duration: 30 minutes.

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Introduction to the numerical treatment of mechanical problems with finite element methods (FEM) based on technical mechanics. Derivation of spring, rod and beam systems. Development of simple elements of continuum mechanics, more advanced finite element techniques such as hybrid methods and boundary element methods. Through detailed deductions in the lectures, the students are then able to develop their own codes for engineering software. The specific aim of this course is a deeper understanding of the construction of numerical processes, so that the students are able to develop software independently. The aim is not to learn how to work with existing software, as this is an area which is continually developing. The emphasis will therefore be placed on the detailed theoretical calculations behind the methods.

**Content**

Spring, rod and beam elements. Introduction to matrix calculations. Derivation of numerical process. Principles of virtual work. Variation principles. Finite element algorithms, boundary element algorithms.

**Literature**

Script (available in administration office, building 10.91, rm. 310).

**Course: Introduction to numerical fluid dynamics [2157444]****Coordinators:** B. Pritz**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Certificate of participation

**Conditions**

Fluid Mechanics (german language) [2153412]

**Recommendations**

Computational Methods in Fluid Mechanics [2157441]

**Learning Outcomes**

Students

- know the three components of CFD: mesh generation, calculation and evaluation.
- will be able to create simple geometries and generate mesh.
- can set up and carry out simulations.
- know the ways of evaluating the results and the possibilities of flow visualization.
- know how to analyze flow situations.

**Content**

In the lab, the components of the cycle of computational fluid dynamics are worked through. In the first instance moderately complicated geometries will be generated and meshed. After the configuration and running the calculation, the results are presented and evaluated in a visualization software. While in the first part of the course these steps are worked out under guidance, calculation cycles are carried out independently in the second part. The test cases are discussed in detail and allow to strengthen the affinity to the fluid dynamics.

Content:

1. Brief introduction into Linux
2. Mesh generation with ICEMCFD
3. Data visualisation and interpretation with Tecplot
4. Handling of the flow solver SPARC
5. Self-designed calculation: flat plate
6. Introduction to unsteady calculations: flow around a circular cylinder

**Literature**

Lecture notes/handout

**Remarks**

In winter term 2012/2013:

Course: Computational Methods in Fluid Mechanics (Exercise) [2157442]

**Course: Wave propagation [2161216]****Coordinators:** W. Seemann**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Optional subject: oral exam, 30 min.

Major subject: oral exam, 20 min.

**Conditions**

Vibration theory

**Learning Outcomes**

The students know several examples of mechanics which can be described by the wave equation in several directions. They can apply D'Alembert's solution. For beams they can decide the range of applicability of different beam theories based on wave propagation phenomena. They can determine the dispersion effects which arise in the models. For wave propagation in a solid they know that characteristic waves may occur which have well determined wave propagation speeds. The students can determine the effects of boundaries and transition surfaces on reflected and transmitted waves. They realize that along boundaries of a half space there may be surface waves of different types.

**Content**

Wave propagation in strings and rods, d'Alembert's solution, initial value problem, boundary conditions, excitation at the boundary, energy transport, wave propagation in beams, Bernoulli-Euler beams, group velocity, beams with changing cross-section, reflexion and transmission, Timoshenko beam theory, wave propagation in membranes and plates, acoustic waves, reflexion and refraction, spherical waves, s- and p-waves in elastic media, reflexion and transmission at bounding surfaces, surface waves

**Literature**

P. Hagedorn and A. Dasgupta: Vibration and waves in Continuous Mechanical Systems, Wiley, 2007

**Course: Introduction to Nonlinear Vibrations [2162247]****Coordinators:** A. Fidlin**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 7            | 4              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 min (optional subject)

20 min (major subject)

Means are not allowed

**Conditions**

None.

**Recommendations**

Vibration theory, mathematical methods of vibration theory, dynamic stability

**Learning Outcomes**

The students

- know the most usual nonlinear effects
- know the minimal models for these effects
- are able to apply perturbation methods for the analysis of nonlinear systems
- know basics of the bifurcation theory
- are able to identify dynamic chaos

**Content**

- dynamic systems
- basic ideas of asymptotic methods
- perturbation methods: Linstedt-Poincare, averaging, multiple scales
- limit cycles
- nonlinear resonance
- basics of the bifurcation analysis, bifurcation diagrams
- types of bifurcations
- discontinuous systems
- dynamic chaos

**Literature**

- Hagedorn P. Nichtlineare Schwingungen. Akademische Verlagsgesellschaft, 1978.
- Nayfeh A.H., Mook D.T. Nonlinear Oscillation. Wiley, 1979.

- Thomsen J.J. Vibration and Stability, Order and Chaos. McGraw-Hill, 1997.
- Fidlin A. Nonlinear Oscillations in Mechanical Engineering. Springer, 2005.
- Bogoliubov N.N., Mitropolskii Y.A. Asymptotic Methods in the Theory of Nonlinear Oscillations. Gordon and Breach, 1961.
- Nayfeh A.H. Perturbation Methods. Wiley, 1973.
- Sanders J.A., Verhulst F. Averaging methods in nonlinear dynamical systems. Springer-Verlag, 1985.
- Blekhman I.I. Vibrational Mechanics. World Scientific, 2000.
- Moon F.C. Chaotic Vibrations – an Introduction for applied Scientists and Engineers. John Wiley & Sons, 1987.

**Course: Electric Rail Vehicles [2114346]****Coordinators:** P. Gratzfeld**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The students know the history of electric traction in railway transportation from the very beginning to modern vehicles with three-phase traction drives.

They know the basics of railway transportation, vehicle dynamics and wheel-rail-contact and can deduct the requirements for electric rail vehicles out of it.

They understand purpose, design and functionality of electric traction drives.

They learn about the different systems of traction power supply with its advantages and disadvantages.

They are informed about actual concepts and new developments in the field of electric railway vehicles.

**Content**

History of electric traction with railway vehicles, economic impact

Vehicle dynamics: running resistance, tractive effort diagram, running cycles

Wheel-rail-contact

Electric drives: traction motors, power conversion, drives for vehicles at dc and ac lines, dieselelectric vehicles, multi system vehicles, axle drives, transmission of tractive effort to the rails

Traction power supply: networks, substations, inductive power supply, energy management

Modern vehicle concepts for mass transit and main line

**Media**

All slides are available for download (Ilias-platform).

**Literature**

A bibliography is available for download (Ilias-platform).

**Course: Elements of Technical Logistics [2117096]****Coordinators:** M. Mittwollen, Madzharov**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

**Learning Control / Examinations**

after each lesson period; oral / written (if necessary) =&gt; (look at "Studienplan Maschinenbau", latest version)

**Conditions**

None.

**Recommendations**

previous / parallel visit of LV 21177095 "Grundlagen der Technischen Logistik"

**Learning Outcomes**

Students are able to:

- Describe elements and systems of technical logistics,
- Model and calculate structures and functions of special conveying machines,
- Describe interdependence of material flow systems and technique quantitatively and qualitatively and
- Equip material flow systems with appropriate machines.

**Content**

material flow systems and their (conveying) technical components

mechanical behaviour of conveyors;

structure and function of conveyor machines; elements of intralogistics (belt conveyor, racks, automatic guided vehicles, fan-in, bifurcation, and etc.)

sample applications and calculations in addition to the lectures inside practical lectures

**Media**

supplementary sheets, projector, blackboard

**Literature**

recommendations during lectures

## Course: Elements of Technical Logistics and Project [2117097]

**Coordinators:** M. Mittwollen, Madzharov

**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

### Learning Control / Examinations

Lesson: after each lesson period; oral / written (if necessary) => (look at "Studienplan Maschinenbau"); (counts two-thirds);

Project: presentation, marked (counts one third)

### Conditions

None.

### Recommendations

previous / parallel visit of LV 21177095 "Grundlagen der Technischen Logistik"

### Learning Outcomes

Students are able to:

- Describe elements and systems of technical logistics,
- Model and calculate structures and functions of special conveying machines,
- Describe interdependence of material flow systems and technique quantitatively and qualitatively,
- Equip material flow systems with appropriate machines and
- Judge about systems in place and justify it in front of subject related persons.

### Content

mechanical behaviour of conveyors;

structure and function of conveyor machines; elements of intralogistics (belt conveyor, racks, automatic guided vehicles, fan-in, bifurcation, and etc.)

sample applications and calculations in addition to the lectures inside practical lectures

Self manufacturing of a project report to recesses the topic.

### Media

supplementary sheets, projector, blackboard

### Literature

recommendations during lectures

**Course: [2157202]****Coordinators:** F. Schmidt**Part of the modules:** SP 55: Energy Technology for Buildings (p. 473)[SP\_55\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations****Conditions**

Can not be combined with the lecture Energy and indoor climate concepts for high performance buildings [1720997]

**Learning Outcomes****Content**

**Course: Energy efficient intralogistic systems [2117500]****Coordinators:** F. Schönung**Part of the modules:** SP 44: Technical Logistics (p. 463)[SP\_44\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral, 30 min, examination dates after the end of each lesson period

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Students are able to:

- Describe and choose basic measures to enhance energy efficiency,
- Specify this measures considering material handling processes like
  - steady conveyors,
  - unsteady conveyors,
  - as well as the necessary drives,
- Model based on this material handling systems and calculate their energy efficiency and
- Choose resource efficient material handling systems.

**Content**

The main focuses of the course are:

- green supply chain
- processes in Intralogistic systems
- evaluation of energy consumption of conveyors
- modeling of conveying systems
- methods for energy savings
- approaches for energy efficiency increasing of continuous and discontinuous conveyors
- dimensioning energy efficient drives
- new approaches for resource efficient conveying systems.

**Media**

presentations, black board

**Literature**

None.

**Remarks**

none

**Course: Energy Systems I: Renewable Energy [2129901]****Coordinators:** R. Dagan**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 53: Fusion Technology (p. 471)[SP\_53\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination – as an elective course 30 minutes, in combination with Energiesysteme II or other courses within the energy courses, as a major course 1 hour

**Conditions**

None.

**Learning Outcomes**

The student knows the principles of the feasibility of energy gain by means of renewable energies, in particular the solar energy.

**Content**

The course deals with fundamental aspects of renewable energies.

1. The first part deals with the basic concepts of absorbing solar beams, in an efficient manner accounting for the minimization of heat losses. In this context, selective topics on Thermodynamics as well as fluid dynamics are introduced. In the second part few applications are discussed and optimizations techniques of solar collectors construction and their heat transfer are presented.
2. The use of solar energy as a source for heat generation is followed by the idea of electricity generation. Introductory aspects of Photovoltaic technologies are illuminated.
3. The last part presents additional regenerative energy sources such as wind and geothermal energy.

**Course: Energy systems II: Reactor Technology [2130926]****Coordinators:** A. Badea**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Summer term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes**

The goal is to get experienced with nuclear, cooling and control engineering calculation methods for the design of nuclear power plants with nuclear fission reactors and with the safety standards in the nuclear industry.

**Content**

nuclear fission & fusion,  
 chain reactions,  
 moderation,  
 light-water reactors,  
 transport- and diffusion-equation,  
 power distributions in reactor,  
 reactor safety,  
 reactor dynamics,  
 design of nuclear reactors,  
 breeding processes,  
 nuclear power systems of generation IV

**Course: Energy Systems II: Nuclear Energy and Reactor Technology [2130921]****Coordinators:** A. Badea**Part of the modules:** SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

oral examination, 30 min.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The students are familiar with nuclear, cooling and control engineering calculation methods for the design of nuclear power plants with nuclear fission reactors and with the safety standards in the nuclear industry.

**Content**

nuclear fission & fusion,  
 chain reactions,  
 moderation,  
 light-water reactors,  
 reactor safety,  
 reactor dynamics,  
 design of nuclear reactors,  
 breeding processes,  
 nuclear power systems of generation IV

**Literature**

slides, lecture notes

Dieter Smidt, Reaktortechnik, 1971 by G. Braun, ISBN 3 7650 2003 6;

D.G. Cacuci, Handbook of Nuclear Engineering, Springer 2010, ISBN 978-0-387-98130-7

## Course: Energy Conversion and Increased Efficiency in Internal Combustion Engines [2133121]

**Coordinators:** T. Koch, H. Kubach

**Part of the modules:** (p. 475)[SP\_58\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral exam, 25 minutes, no auxillary means

### Conditions

None.

### Recommendations

especially reasonable in combination with lecture "Fundamentals of Combustion Engines I"

### Learning Outcomes

The students can name all important influences on the combustion process. They can analyse and evaluate the engine process considering efficiency, emissions and potential.

### Content

reaction kinetics  
 fuels  
 gas exchange  
 ignition  
 flow field of gasoline engines  
 working process  
 pressure trace analysis  
 thermodynamic analysis of the high pressure process  
 exergy analysis and waste heat recuperation  
 aspects of sustainability

## Course: Design Project Machine Tools and Industrial Handling [2149903]

**Coordinators:** J. Fleischer

**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

The Design Project Machine Tools and Industrial Handling can only be combined with the lecture Machine Tools and Industrial Handling (Lecture-No. 2149902). The number of students is limited to five.

### Recommendations

None

### Learning Outcomes

The students . . .

- are able to solve a specified task in a team.
- have the ability to analyze a given work piece, to select the necessary manufacturing process and to deduce a suitable manufacturing strategy.
- are qualified to identify the required movements of work piece and tool.
- are enabled to select the essential components and assemblies as well as execute the necessary design and calculations of dimensions.
- have the ability to interpret and present their designs and calculations.
- are capable of performing FEA analysis regarding dynamic and static behavior of the machine tool.
- are qualified to perform the essential methods for design at optimal cost, detect potentials for cost reduction and solve the given task within target costs.
- are enabled to practice the learned knowledge and methods of Machine Tools and Industrial Handling on an actual example.

### Content

The tutorial Design Project Machine Tools and Industrial Handling provides an inside view of machine tool development. Within the project the students are enabled to design a machine tool for a specified work piece selected by a corporate partner.

First a machining strategy is deduced. With this strategy the students are enabled to calculate the relevant technological specifications and to dimension the necessary components such as feed axes, frame, bed and main spindle. In the end the machine tool is designed and optimized with FEA methods. Aside a target costing approach is executed for remaining within the specified costs.

The Project is executed by the students under the instruction and in cooperation with the corporate partner. It offers

- a unique opportunity to implement the learned knowledge interdisciplinary and creatively.
- inside views into manifold development and design work.
- Co-operation with first-grade cooperate partners.
- work within a student team and professional support by research associates.

**Media**

SharePoint, wiki, Catia V5R20

**Literature**

None

**Remarks**

None

**Course: Organ support systems [2106008]****Coordinators:** C. Pylatiuk**Part of the modules:** SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral, also possible as an optional or part of a major subject

**Conditions**

None.

**Recommendations**

Fundamentals of medicine

**Learning Outcomes**

Students have fundamental knowledge about functionality of organ support systems and its components. An analysis of historical developments can be done and limitations of current systems can be found. The limits and possibilities of transplantations can be elaborated.

**Content**

- Introduction: Definitions and classification of organ support and replacement.
- Special topics: acoustic and visual prostheses, exoskeletons, neuroprostheses, tissue-engineering, hemodialysis, heart-lung machine, artificial hearts, biomaterials.

**Literature**

- Jürgen Werner: Kooperative und autonome Systeme der Medizintechnik: Funktionswiederherstellung und Organersatz. Oldenbourg Verlag.
- Rüdiger Kramme: Medizintechnik: Verfahren - Systeme – Informationsverarbeitung. Springer Verlag.
- E. Wintermantel, Suk-Woo Ha: Medizintechnik. Springer Verlag.

**Course: Experimental Dynamics [2162225]****Coordinators:** A. Fidlin, H. Hetzler**Part of the modules:** SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 min (optional subject)

20 min (major subject)

Means are not allowed

**Conditions**

None.

**Recommendations**

Vibration theory, mathematical methods of vibration theory, dynamic stability, nonlinear vibrations

**Learning Outcomes**

- To learn the basic principles for dynamic measurements
- To learn the basics of the experimental model validation
- To get the first experience in the digital data analysis
- To learn the limits of the minimal models
- To be able to perform simple measurements

**Content**

1. Introduction
2. Measurement principles
3. Sensors as coupled multi-physical systems
4. Digital signal processing, measurements in frequency domain
5. Forced non-linear vibrations
6. Stability problems (Mathieu oscillator, friction induces vibrations)
7. Elementary rotor dynamics
8. Modal analysis

**Remarks**

The lectures will be accompanied by the laboratory experiments

**Course: Experimental Fluid Mechanics [2154446]****Coordinators:** J. Kriegseis**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

no auxiliary means

**Conditions**

None.

**Recommendations**

Fundamental Knowledge about Fluid Mechanics

**Learning Outcomes**

The students can describe the relevant physical principles of experimental fluid mechanics. They are qualified to comparatively discuss the introduced measurement techniques. Furthermore, they are able to distinguish (dis-)advantages of the respective approaches. The students can evaluate and discuss measurement signal and data obtained with the common fluid mechanical measuring techniques.

**Content**

This lecture focuses on experimental methods of fluid mechanics and their application to solve flow problems of practical relevance. In addition, measurement signals and data, obtained with the discussed measuring techniques, are evaluated, presented and discussed.

The lecture covers a selection of the following topics:

- measuring techniques and measureable quantities
- measurements in turbulent flows
- pressure measurements
- hot wire measurements
- optical measuring techniques
- error analysis
- scaling laws
- signal and data evaluation

**Media**

Slides, chalk board, overhead

**Literature**

Tropea, C., Yarin, A.L., Foss, J.F.: Springer Handbook of Experimental Fluid Mechanics, Springer 2007  
 Spurk, J.H.: Fluid Mechanics, Springer, 1997

**Course: Metallographic Lab Class [2175590]****Coordinators:** K. von Klinski-Wetzel**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 3              | Winter / Summer Term |                      |

**Learning Control / Examinations**

Colloquium with every experiment, Laborjournal

**Conditions**

basic knowledge in materials science (e.g. lecture materials science I and II)

**Learning Outcomes**

The students in this lab class gain are able to perform standard metallographic preparations and are able to apply standard software for quantitative microstructural analyses. Based on this the student can interpret unetched as well as etched microstructures with respect to relevant microstructural features. They can draw concluding correlations between heat treatments, ensuing microstructures and the resulting mechanical as well as physical properties of the investigated materials.

**Content**

Light microscope in metallography

metallographic sections of metallic materials

Investigation of the microstructure of unalloyed steels and cast iron

Microstructure development of steels with accelerated cooling from the austenite area

Investigation of microstructures of alloyed steels

Investigation of failures quantitative microstructural analysis

Microstructural investigation of technically relevant non-ferrous metals  
(e. g. copper-, aluminium-, nickel-, titanium-and tin-based alloys)

**Literature**

E. Macherauch: Praktikum in Werkstoffkunde, 10th edition, 1992

H. Schumann: Metallographie, 13th edition, Deutscher Verlag für Grundstoffindustrie, 1991

Literature List will be handed out with each experiment

**Course: Welding Lab Course, in groupes [2173560]****Coordinators:** J. Hoffmeister**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

**Learning Control / Examinations**

Certificate to be issued after evaluation of the lab class report

**Conditions**

Certificate of attendance for Welding technique I

**Learning Outcomes**

The students are capable to name a survey of current welding processes and their suitability for joining different metals. The students can evaluate the advantages and disadvantages of the individual procedures. The students have weld with different welding processes.

**Content**

Gas welding of steels with different weld geometries

Gas welding of cast iron, nonferrous metals

Brazing of aluminum

Electric arc welding with different weld geometries

Gas welding according to the TIG, MIG and MAG procedures

**Literature**

distributed during the lab attendance

**Remarks**

The lab takes place at the beginning of the winter semester break once a year. The registration is possible during the lecture period in the secretariat of the Institute of Applied Materials (IAM – WK). The lab is carried out in the Handwerkskammer Karlsruhe.

You need sturdy shoes and long clothes!

**Course: Handling Characteristics of Motor Vehicles I [2113807]****Coordinators:** H. Unrau**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Verbally

Duration: 30 up to 40 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students know the basic connections between drivers, vehicles and environment. They can build up a vehicle simulation model, with which forces of inertia, aerodynamic forces and tyre forces as well as the appropriate moments are considered. They have proper knowledge in the area of tyre characteristics, since a special meaning comes to the tire behavior during driving dynamics simulation. Consequently they are ready to analyze the most important influencing factors on the driving behaviour and to contribute to the optimization of the handling characteristics.

**Content**

1. Problem definition: Control loop driver - vehicle - environment (e.g. coordinate systems, modes of motion of the car body and the wheels)
2. Simulation models: Creation from motion equations (method according to D'Alembert, method according to Lagrange, programme packages for automatically producing of simulation equations), model for handling characteristics (task, motion equations)
3. Tyre behavior: Basics, dry, wet and winter-smooth roadway

**Literature**

1. Willumeit, H.-P.: Modelle und Modellierungsverfahren in der Fahrzeugdynamik, B. G. Teubner Verlag, 1998
2. Mitschke, M./Wallentowitz, H.: Dynamik von Kraftfahrzeugen, Springer-Verlag, Berlin, 2004
3. Gnadler, R.; Unrau, H.-J.: Reprint collection to the lecture Handling Characteristics of Motor Vehicles I

**Course: Handling Characteristics of Motor Vehicles II [2114838]****Coordinators:** H. Unrau**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students have an overview of common test methods, with which the handling of vehicles is gauged. They are able to interpret results of different stationary and transient testing methods. Apart from the methods, with which e.g. the driveability in curves or the transient behaviour from vehicles can be registered, also the influences from cross-wind and from uneven roadways on the handling characteristics are well known. They are familiar with the stability behavior from single vehicles and from vehicles with trailer. Consequently they are ready to judge the driving behaviour of vehicles and to change it by specific vehicle modifications.

**Content**

1. Vehicle handling: Bases, steady state cornering, steering input step, single sine, double track switching, slalom, cross-wind behavior, uneven roadway

2. stability behavior: Basics, stability conditions for single vehicles and for vehicles with trailer

**Literature**

1. Zomotor, A.: Fahrwerktechnik: Fahrverhalten, Vogel Verlag, 1991

2. Mitschke, M./Wallentowitz, H.: Dynamik von Kraftfahrzeugen, Springer-Verlag, Berlin, 2004

3. Gnadler, R. Unrau, H.-J.: Reprint collection to the lecture Handling Characteristics of Motor Vehicles II

**Course: Vehicle Comfort and Acoustics I [2113806]****Coordinators:** F. Gauterin**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], (p. 475)[SP\_58\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

**Conditions**

Can not be combined with lecture [2114856]

**Recommendations**

None.

**Learning Outcomes**

The students know what noises and vibrations mean, how they are generated, and how they are perceived by human beings.

They have knowledge about the requirements given by users and the public. They know which components of the vehicle are participating in which way on noise and vibration phenomenon and how they could be improved. They are ready to apply different tools and methods to analyze relations and to judge them. They are able to develop the chassis regarding driving comfort and acoustic under consideration of goal conflicts.

**Content**

1. Perception of noise and vibrations
3. Fundamentals of acoustics and vibrations
3. Tools and methods for measurement, computing, simulation and analysis of noise and vibrations
4. The relevance of tire and chassis for the acoustic and mechanical driving comfort: phenomena, influencing parameters, types of construction, optimization of components and systems, conflict of goals, methods of development

An excursion will give insights in the development practice of a car manufacturer or a system supplier.

**Literature**

1. Michael Möser, Technische Akustik, Springer, Berlin, 2005
2. Russel C. Hibbeler, Technische Mechanik 3, Dynamik, Pearson Studium, München, 2006
3. Manfred Mitschke, Dynamik der Kraftfahrzeuge, Band B: Schwingungen, Springer, Berlin, 1997

The script will be supplied in the lectures

**Course: Vehicle Comfort and Acoustics II [2114825]****Coordinators:** F. Gauterin**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], (p. 475)[SP\_58\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

**Conditions**

Can not be combined with lecture [2114857]

**Recommendations**

None.

**Learning Outcomes**

The students have knowledge about the noise and vibration properties of the chassis components and the drive train. They know what kind of noise and vibration phenomena do exist, what are the generation mechanisms behind, which components of the vehicle participate in which way and how could they be improved. They have knowledge in the subject area of noise emission of automobiles: Noise impact, legal requirements, sources and influencing parameters, component and system optimization, target conflicts and development methods. They are ready to analyze, to judge and to optimize the vehicle with its single components regarding acoustic and vibration phenomena. They are also able to contribute competently to the development of a vehicle regarding the noise emission.

**Content**

1. Summary of the fundamentals of acoustics and vibrations
2. The relevance of road surface, wheel imperfections, springs, dampers, brakes, bearings and bushings, suspensions, engines and drive train for the acoustic and mechanical driving comfort:
  - phenomena
  - influencing parameters
  - types of construction
  - optimization of components and systems
  - conflicts of goals
  - methods of development
3. Noise emission of motor vehicles
  - noise stress
  - sound sources and influencing parameters
  - legal restraints
  - optimization of components and systems
  - conflict of goals
  - methods of development

**Literature**

The script will be supplied in the lectures.

**Course: Introduction to Automotive Lightweight Technology [2113102]****Coordinators:** F. Henning**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach], SP 36: Polymer Engineering (p. 454)[SP\_36\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

verbally

duration: 20 - 30 min

auxiliary means: none

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Students learn that lightweight design is a process of realizing a demanded function by using the smallest possible mass. They understand lightweight construction as a complex optimization problem with multiple boundary conditions, involving competences from methods, materials and production.

Students learn the established lightweight strategies and ways of construction. They know the metallic materials used in lightweight construction and understand the relation between material and vehicle body.

**Content**

strategies in lightweight design

shape optimization, light weight materials, multi-materials and concepts for lightweight design

construction methods

differential, integral, sandwich, modular, bionic

body construction

shell, space frame, monocoque

metallic materials

steel, aluminium, magnesium, titan

**Course: Vehicle Mechatronics I [2113816]****Coordinators:** D. Ammon**Part of the modules:** SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Written examination

Duration: 90 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students have an overview of the system science field of mechatronics and its application in the area of vehicle conception, especially in the context of vehicle system dynamics. They know the tools and methods for a systematic analysis, conception, and design of mechatronic systems, focussing on mechatronically extended suspension systems. They are ready to analyze, to judge and to optimize mechatronic systems.

**Content**

1. Introduction: Mechatronics in vehicle technology
2. Vehicle Control systems  
Brake- and traction controls (ABS, ASR, automated power train controls)  
Active and semiactive suspension systems, active stabilizer bars  
Vehicle dynamics controls, driver assistance systems
3. Modelling technology  
Mechanics - multi body dynamics  
Electrical and electronical systems, control systems  
Hydraulics  
Interdisciplinary coupled systems
4. Computer simulation technology  
Numerical integration methods  
Quality (validation, operating areas, accuracy, performance)  
Simulator-coupling (hardware-in-the-loop, software-in-the-loop)
5. Systemdesign (example: brake control)  
Demands, requirements (funktion, safety, robustness)  
Problem setup (analysis - modelling - model reduction)  
Solution approaches  
Evaluation (quality, efficiency, validation area, concept ripeness)

**Literature**

1. Ammon, D., Modellbildung und Systementwicklung in der Fahrzeugdynamik, Teubner, Stuttgart, 1997
2. Mitschke, M., Dynamik der Kraftfahrzeuge, Bände A-C, Springer, Berlin, 1984ff
3. Miu, D.K., Mechatronics - Electromechanics and Contromechanics, Springer, New York, 1992
4. Popp, K. u. Schiehlen, W., Fahrzeugdynamik - Eine Einführung in die Dynamik des Systems Fahrzeug-Fahrweg, Teubner, Stuttgart, 1993
5. Roddeck, W., Einführung in die Mechatronik, Teubner, Stuttgart, 1997
6. Zomotor, A., Fahrwerktechnik: Fahrverhalten, Vogel, Würzburg, 1987

**Course: Basics and Methods for Integration of Tires and Vehicles [2114845]****Coordinators:** G. Leister**Part of the modules:** SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

**Conditions**

Knowledge in automotive engineering

**Learning Outcomes**

The students are informed about the interactions of tires, chassis and road. They have an overview of the processes regarding the tire development. They have knowledge of the physical relationships. They are ready to analyze and to judge the mentioned interactions. They are able to participate competently in the chassis development.

**Content**

1. The role of the tire in a vehicle
2. Tire geometrie, Package and load capacity, Book of requirement
3. Mobility strategy, Minispare, runflat systems and repair kit.
4. Project management: Costs, weight, planning, documentation
5. Tire testing and tire properties: Forces and Moments
6. Tire modes and sound
7. Tire pressure: Indirect and direct measuring systems
8. Tire testing subjective and objective

**Literature**

Manuscript to the lecture

**Course: Automotive Vision [2138340]****Coordinators:** C. Stiller, M. Lauer**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 19: Information Technology of Logistic Systems (p. 431)[SP\_19\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 50: Rail System Technology (p. 469)[SP\_50\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes

no reference materials

**Conditions**

Fundamentals in measurement, system and control theory, e.g. from the lecture "Measurement and Control Systems"

**Learning Outcomes**

Machine perception and interpretation of the environment for the basis for the generation of intelligent behaviour. Especially visual perception opens the door to novel automotive applications. First driver assistance systems can already improve safety, comfort and efficiency in vehicles. Yet, several decades of research will be required to achieve an automated behaviour with a performance equivalent to a human operator. The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Machine vision, vehicle kinematics and advanced information processing techniques are presented to provide a broad overview on 'Being vehicles'. Application examples from cutting-edge and future driver

assistance systems illustrate the discussed subjects.

**Content**

1. Driver assistance systems
2. Image acquisition and discretization
3. Image signal processing
4. Stochastic image models
5. Stereo vision and image sequence processing
6. Tracking
7. Lane recognition
8. Obstacle recognition

**Literature**

TBA

**Course: Composites for Lightweight Design [2114053]****Coordinators:** F. Henning**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach], SP 36: Polymer Engineering (p. 454)[SP\_36\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

verbally

duration: 20 - 30 min

auxiliary means: none

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Students know different polymer resin materials and fiber materials and can deduce their character and use.

They understand the reinforcing effect of fibers in a matrix surrounding as well as the tasks of the single components in a compound. They know about the influence of the length of fibers, their mechanical characters and performance in a polymer matrix compound.

Student know the important industrial production processes for continuous and discontinuous reinforced polymer matrix compounds.

**Content**

Physical connections of fiber reinforcement

Use and examples

automotive construction

transport

Energy and construction

sport and recreation

resins

thermoplastics

duromeres

mechanisms of reinforcements

glas fibers

carbon fibers

aramid fibers

natural fibers

semi-finished products - textiles

process technologies - prepregs

recycling of composites

**Course: FEM Workshop – constitutive laws [2183716]****Coordinators:** K. Schulz, D. Weygand**Part of the modules:** SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral examination in the elective module MSc, otherwise no grading  
 solving of a FEM problem  
 preparation of a report  
 preparation of a short presentation

**Conditions**

None.

**Recommendations**

Engineering Mechanics; Advanced Mathematics; Introduction to Theory of Materials

**Learning Outcomes**

The student

- has the basic understanding of the materials theory and the classification of materials
- is able to independently generate numerical models using ABAQUS and can choose and apply adequate constitutive equations

**Content**

The course repeats the fundamentals of the theory of materials. It leads to the characterization and classification of material behavior as well as the specification by adequate material models. Here we focus on elastic, viscoelastic, plastic, and viscoplastic deformation behavior. Introducing the finite element program ABAQUS, the students learn how to analyze the material models numerically. Therefore ABAQUS-own and continuative constitutive equations are chosen.

**Literature**

Peter Haupt: Continuum Mechanics and Theory of Materials, Springer; ABAQUS Manual; Lecture notes

**Course: Fabrication Processes in Microsystem Technology [2143882]****Coordinators:** K. Bade**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral examination, 20 minutes

**Conditions**

Bachelor mach., wing.

**Recommendations**

Lectures

Mikrosystemtechnik I [2141861] and/or II [2142874]

**Learning Outcomes**

The student

- collects advanced knowledge
- understands process conditions and process layout
- gains interdisciplinary knowledge (chemistry, manufacturing, physics)

**Content**

The lecture offers an advanced understanding of manufacturing processes in microsystem technology. Basic aspects of microtechnological processing will be introduced. With examples from semiconductor microfabrication and microsystem technology the base processing steps for conditioning and finishing, patterning, removal are imparted. Nano-patterning is covered is also included and the micro-nano interface is discussed. By the help of typical processing steps elementary mechanisms, process execution, and equipment are explained. Additionally quality control, process control and environmental topics are included

**Media**

pdf files of presentation sheets

**Literature**

M. Madou

Fundamentals of Microfabrication

CRC Press, Boca Raton, 1997

W. Menz, J. Mohr, O. Paul

Mikrosystemtechnik für Ingenieure

Dritte Auflage, Wiley-VCH, Weinheim 2005

L.F. Thompson, C.G. Willson, A.J. Bowden

Introduction to Microlithography

2<sup>nd</sup> Edition, ACS, Washington DC, 1994

## Course: Manufacturing Technology [2149657]

**Coordinators:** V. Schulze, F. Zanger

**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 6              | Winter term | de                   |

### Learning Control / Examinations

The assessment is carried out as a written exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None

### Recommendations

None

### Learning Outcomes

The students ...

- are capable to specify the different manufacturing processes and to explain their functions.
- are able to classify the manufacturing processes by their general structure and functionality according to the specific main groups.
- have the ability to perform a process selection based on their specific characteristics.
- are enabled to identify correlations between different processes and to select a process regarding possible applications.
- are qualified to evaluate different processes regarding specific applications based on technical and economic aspects.
- are experienced to classify manufacturing processes in a process chain and to evaluate their specific influence on surface integrity of workpieces regarding the entire process chain.

### Content

The objective of the lecture is to look at manufacturing technology within the wider context of production engineering, to provide an overview of the different manufacturing processes and to impart detailed process knowledge of the common processes. The lecture covers the basic principles of manufacturing technology and deals with the manufacturing processes according to their classification into main groups regarding technical and economic aspects. The lecture is completed with topics such as process chains in manufacturing.

The following topics will be covered:

- Quality control
- Primary processing (casting, plastics engineering, sintering, additive manufacturing processes)
- Forming (sheet-metal forming, massive forming, plastics engineering)
- Cutting (machining with geometrically defined and geometrically undefined cutting edges, separating, abrading)
- Joining
- Coating
- Heat treatment and surface treatment
- Process chains in manufacturing

This lecture provides an excursion to an industry company.

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

## Course: Solid State Reactions and Kinetics of Phase Transformations (with exercises) [2193003]

**Coordinators:** P. Franke, K. Krüger

**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral examination (30 min)

### Conditions

- Basic course in materials science and engineering
- physical chemistry

### Recommendations

none

### Learning Outcomes

The students acquire knowledge about:

- diffusion mechanisms
- Fick's laws
- basic solutions of the diffusion equation
- evaluation of diffusion experiments
- interdiffusion processes
- the thermodynamic factor
- parabolic growth of layers
- formation of pearlite
- microstructural transformations according to the models of Avrami and Johnson-Mehl
- TTT diagrams

### Content

1. Crystal Defects and Mechanisms of Diffusion
2. Microscopic Description of Diffusion
3. Phenomenological Treatment
4. Diffusion Coefficients
5. Diffusion Problems; Analytical Solutions
6. Diffusion with Phase Transformation
7. Kinetics of Microstructural Transformations
8. Diffusion at Surfaces, Grain Boundaries and Dislocations

### Literature

1. J. Crank, „The Mathematics of Diffusion“, 2nd Ed., Clarendon Press, Oxford, 1975.
2. J. Philibert, „Atom Movements“, Les Éditions de Physique, Les Ulis, 1991.
3. D.A. Porter, K.E. Easterling, M.Y. Sherif, „Phase Transformations in Metals and Alloys“, 3rd edition, CRS Press, 2009.
4. H. Mehrer, „Diffusion in Solids“, Springer, Berlin, 2007.

## Course: Finite Element Workshop [2182731]

**Coordinators:** C. Mattheck, D. Weygand

**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

certificate in case of regular attendance

### Conditions

Continuum Mechanics

### Learning Outcomes

The student can

- perform stress analysis for simple components using the commercial software package ANSYS
- utilise the method of the tensile triangle to optimize the shape of components with respect to stress distribution

### Content

The students will learn the foundations of the FEM stress analysis and the optimization methode 'Zugdreiecke'.

**Course: Finite Volume Methods for Fluid Flow [2154431]****Coordinators:** C. Günther**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

no auxiliary means

**Conditions**

None.

**Recommendations**

Fundamental Knowledge about Fluid Mechanics

**Learning Outcomes**

Students can describe all fundamental aspects of the finite volume methods, which form the basis for a number of different commercial CFD codes.

**Content**

The Finite Volume Method (=FVM) is nowadays of great interest, as it guarantees conservation of all relevant variables and as it can be used on nearly arbitrary meshes. By this it is a fundamental tool for numerical simulation of flows, which plays an ever growing role for construction and engineering and is the basis of several commercial or research codes as CFX, STAR-CCM+, FLUENT or OpenFOAM. The lecture is concerned with all aspects of FVM, mesh generation is also included. Newer developments as CVFEM (control volume based FEM) are described.

- Introduction
- Conservative schemes
- Finite volume method
- Analysis of FVM
- CVFEM as conservative FEM
- FVM for Navier-Stokes Equations
- Basics of mesh generation

**Remarks**

The lecture is recommended for students of mechanical, chemical or electrical engineering and is also of interest for people which are interested in FVM in a context other than fluid flow problems.

**Course: Fluid-Structure-Interaction [2154401]****Coordinators:** M. Mühlhausen**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral exam

Duration: 30 min

no auxiliary means

**Conditions**

none

**Recommendations**

Basic Knowledge about Fluid Mechanics

**Learning Outcomes**

The students are familiar with the numerical treatment of coupled problems. After completing this course students are able to describe a fluid-structure coupled problem and to derive its numerical formulation. They are familiar with the different coupling possibilities between the two regions and the corresponding advantages and disadvantages. Finally, the students are aware of the fact that not every result of a numerical simulation necessarily reflects reality and can thus critically judge the numerically obtained results.

**Content**

The lecture first introduces/recalls the fundamental governing equations that describe fluids and structures. After the characterization of the problem, the relevant equations are discussed and geometry and grid generation are treated. The resulting partial differential equations are transformed into an algebraic set of equations using different DFG and CSD methods and discretization schemes. Different methods for fluid structure coupling are introduced, where the resulting stability problem is treated in detail. Finally, the obtained result is critically examined in terms of errors and inaccuracy and verification and validation procedures are introduced.

The lecture includes an introduction to function of CFG-Programs and Matlab routines that are related to the theoretically discussed approaches.

**Literature**

will be introduced during the lecture

**Remarks**

Block course with limited number of participants, registration in the secretary's office required.

See details at [www.istm.kit.edu](http://www.istm.kit.edu)

**Course: Fluid Mechanics of Turbulent Flows [6221806]****Coordinators:** M. Uhlmann**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

**Learning Control / Examinations**

graded:

oral examination, 30 minutes

**Conditions**

None.

**Learning Outcomes**

Introduction to the physics of turbulent flows and the problem of computing them, statistical analysis of turbulent field data, detailed description of currently used statistical turbulence models (Reynolds-averaging as well as spatial filtering), discussion of model performance and range of applicability

**Content**

Fluid Mechanics of Turbulent Flows: General introduction to turbulent flows, Equations of fluid motion, Statistical description of turbulence, Free shear flows, The scales of turbulent motion, Wall-bounded shear flows, DNS as numerical experiments

**Literature**

Literature: S.B. Pope "Turbulent flows", Cambridge University Press, 2000. U. Frisch "Turbulence: The legacy of A.N. Kolmogorov", Cambridge U. Press, 1995. P.A. Durbin and P.A. Petterson Reif. "Statistical theory and modeling for turbulent flows", Wiley, 2001. D.C. Wilcox "Turbulence Modeling for CFD", DCW Industries, second edition, 1998.

**Course: Fluid Technology [2114093]****Coordinators:** M. Geimer, M. Scherer**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 4              | Winter term | de                   |

**Learning Control / Examinations**

The assessment consists of a written exam (2 hours) taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

**Conditions**

None.

**Learning Outcomes**

The students will be able to

- know and understand physical principles of fluid power systems
- know the current components and their operating mode
- know the advantages and disadvantages of different components
- dimension the components for a given purpose
- calculate simple systems

**Content**

In the range of hydrostatics the following topics will be introduced:

- Hydraulic fluids
- Pumps and motors
- Valves
- Accessories
- Hydraulic circuits.

In the range of pneumatics the following topics will be introduced:

- Compressors
- Motors
- Valves
- Pneumatic circuits.

**Literature**

Scritum for the lecture *Fluidtechnik*  
 Institute of Vehicle System Technology  
 downloadable

**Course: Functional Ceramics [2126784]****Coordinators:** M. Hoffmann, M. Bäurer**Part of the modules:** SP 43: Technical Ceramics and Powder Materials (p. 462)[SP\_43\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (20 min) taking place at the agreed date.

Auxiliary means: none

The re-examination is offered upon agreement.

**Conditions**

none

**Recommendations**

Basics of the course "Introduction to Ceramics" should be known.

**Learning Outcomes**

The students know the correlation among crystal structure, defect chemistry and electrical, dielectric and piezoelectric properties and are familiar with the different methods for powder preparation, shaping and sintering. They know the functionality and application fields of semiconducting, piezoelectric and pyroelectric ceramics.

**Content**

The course gives an introduction to physics and chemistry of functional ceramics, provides an overview of the corresponding processing methods and highlights the properties and application of the most relevant materials.

It is arranged in the following units:

- Crystal structures and defect chemistry
- Thermodynamic of interfaces and grain boundaries
- Methods for the preparation of functional ceramics
- Dielectric materials and insulators
- Semiconducting ceramics (varistors, PTC- und NTC-ceramics)
- Ion conductive ceramics (oxygen sensors, solid oxid fuel cells)
- Piezoelectric ceramics
- Pyroelectric ceramics
- Elektrooptical ceramics

**Media**

Slides for the lecture:

available under <http://www.iam.kit.edu/km/289.php>

**Literature**

Y.-M. Chiang, D. Birnie III and W.D. Kingery, "Physical Ceramics", Wiley (1997)

A.J. Moulson, J.M. Herbert, "Electroceramics, Materials - Properties - Applications", Chapman and Hall (1990)

Y. Xu, "Ferroelectric Materials and Their Applications", Elsevier (1991)

H. Jaffe, W.R. Cook and H. Jaffe, "Piezoelectric Ceramics", Academic Press (1971)

**Remarks**

The course will not take place every year

**Course: Fusion Technology A [2169483]****Coordinators:** R. Stieglitz**Part of the modules:** SP 53: Fusion Technology (p. 471)[SP\_53\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral: Acceptance for the oral test only by certification of attendance of exercises

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

Basic knowledge in fluid mechanics, material sciences and physics

**Recommendations**

appreciated is knowledge in heat and mass transfer as well as in electrical engineering

**Learning Outcomes**

The lecture describes the functional principle of a fusion reactor, starting from the plasma, the magnets, the tritium and fuel cycle, the vacuum technology and the associated material sciences. The physical principles are discussed and scaling laws are formulated. One major emphasis is directed towards the interface between the individual fields of disciplines which to a large extent determines the technological scaling of a fusion facility. Here methods are communicated, which allow for an identification of central parameters and a corresponding technical analysis. Based on the elaborated acquisition skills approaches to design solution strategies are transmitted. Also technical solutions are shown and the weaknesses are discussed and evaluated.

**Content**

Actual energy situation and perspectives. Transfer of the fundamentals in structure of matter physics, fusion and nuclear fission, plasma. Ignition conditions of a plasma, plasma instabilities, control of a plasma and transport in plasmas. Magnet technology, super-conductivity, materials in super-conductivity, fabrication and design of magnets, tritium and fuel cycle, vacuum technology in fusion. The individual sections describe additionally the task, the challenges and the design of state of the art technology. Also an introduction into design criteria and materials for fusion are given, which scopes the fundamentals of material science, characterization of fusion materials, material damage by irradiation and calculation methods for nuclear materials. Additionally hints for an adequate material selection are presented.

**Literature**

Within each subblock an adequate selection of literature is given. Additionally the students get the lecture materials in printed and electronic version.

**Course: Fusion Technology B [2190492]****Coordinators:** R. Stieglitz**Part of the modules:** SP 53: Fusion Technology (p. 471)[SP\_53\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Completed set of practical courses within lecture

Duration: approximately 25 minutes

no tools or reference materials may be used during the exam

**Conditions**

reliable capability to use fundamental knowledge communicated in the bachelor study in physics, heat. and mass transfer and engineering design

**Recommendations**

attendance of fusion technology A lecture

**Learning Outcomes**

The lecture comprising two semesters is addressing students of engineering science and physics after a successful intermediate diploma. It intends to give an introduction to current fusion research and development and to the long term target of fusion as a promising energy source. After a short insight into fusion physics the lecture concentrates on key technologies for future fusion reactors. The lectures are complemented by exercises at different institutes located at the campus north (two to three afternoons per subject).

**Content**

Die Fusionstechnologie B beinhaltet

Fusion neutronics, plasma facing components and plasma heating-and current drive methods. The section fusion neutronics scopes the fundamentals and calculation methods, which allows for a physical design of a nuclear fusion reactor and the corresponding components (such as blankets, divertors, shielding, activation and dose rate). Fusion reactors produce fuel their "self". The necessary blankets are complex structures whose foundations and concept options, design criteria and methods are discussed. Also the divertor is a plasma facing component. Its tasks, constraints, and design concepts are explained. The arrangement of the plasma facing components in a fusion power plant means changing demands on the system integration and energy conversion. To ignite the plasma extreme temperatures of several million degrees are required. For this purpose, special plasma heating techniques are used such as electron cyclotron resonance heating (ECRH), ion-cyclotron resonance heating (ICRH), the current drive at the lower hybrid frequency, and the neutral particle injection. Their basic mode of action, the design criteria, the transmission options and performance are presented and discussed. Additionally the heating method used also for plasma stabilization. Here are some considerations and limitations are presented.

**Literature**

Lecture notes

McCracken, Peter Scott, Fusion, The Energy of Universe, Elsevier Academic Press, ISBN: 0-12-481851-X

**Course: Combined Cycle Power Plants [2170490]****Coordinators:** T. Schulenberg**Part of the modules:** SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

Oral Examination 30 min

**Conditions**

Knowledge in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.

**Recommendations**

We recommend to combine the lecture with the Simulator Exercises for Combined Cycle Power Plants (2710491)

**Learning Outcomes**

The students know the design and operation principles of major components of advanced combined cycle power plants including their control, as well as the dynamic response of combined cycle power plants to grid requirements.

**Content**

Layout of a combined cycle power plant, design and operation of gas turbines, of the heat recovery steam generator, of the feedwater system and cooling systems. Design and operation of steam turbines, of the generator and its electrical systems. System response to challenging grids, protection systems, water make-up and water chemistry. Design concepts of different power plant manufacturers, innovative power plant concepts.

**Media**

Lecture with English Power Point Presentation

**Literature**

Power point slides and other lecture material will be provided.

Recommended additional literature:

C. Lechner, J. Seume, Stationäre Gasturbinen, Springer Verlag, 2. Auflage 2010

**Course: [2154200]****Coordinators:** F. Magagnato**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], (p. 475)[SP\_58\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 min

no auxiliary means

**Conditions**

none

**Recommendations**

basic skills in mathematics, physics and fluid dynamics

**Learning Outcomes**

The students can describe the governing equations of Gas Dynamics in integral form und the associated basics in Thermodynamics. They can calculate compressible flows analytically. The students are familiar with the Rankine-Hugoniot curve and the Rayleigh line and can name those. They can derive the continuity-, the momentum- and the energy equations in differential form. With the help of the stationary flow filament theory they can calculate the normal shock wave and the associated increase of entropy.

They are able to determine the stagnation values of the gas dynamic variables and to determine their critical values. The students can apply the flow filament theory for variable cross-sectional areas and can distinguish the related different flow states inside the Laval nozzle.

**Content**

This lecture covers the following topics:

- Introduction, basics of Thermodynamics
- Governing equations of gas dynamics
- Application of the conservation equations
- The transport equations in differential form
- Stationary flow filament theory with and without shock waves
- Discussion of the energy equation: Stagnation and critical values
- Flow filament theory for variable cross-sectional areas. Flow inside a Laval nozzle

**Literature**

John, J., and Keith T. Gas Dynamics. 3rd ed.

Harlow: Prentice Hall, 2006

Rathakrishnan, E. *Gas Dynamics*. Prentice Hall of India Pvt. Ltd, 2006

**Course: Gas Engines [2134141]**

**Coordinators:** R. Golloch  
**Part of the modules:** (p. 475)[SP\_58\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

**Learning Control / Examinations**

Oral examination, duration 25 min., no auxillary means

**Conditions**

none

**Recommendations**

Knowledge about „Verbrennungsmotoren A und B“ or “Fundamentals of Combustion Engines I and II”

**Learning Outcomes**

The student can name and explain the function, characteristics and application areas of gas and dual fuel engines. He is able to distinguish from engines using liquid fuels. The student describe and explain gaseous fuels, engine subsystems, combustion processes and exhaust gas aftertreatment technologies. He is capable to analyse and evaluate current development areas and technical challenges.

**Content**

Based on the basics of internal combustion engines the students learn about functions of modern gas and dual fuel engines. Core learning areas are gaseous fuels, combustion processes including abnormal combustion characteristics, subsystems like gas admission, ignition, safety and control systems. Further knowledge will be taught on emissions, exhaust gas aftertreatment, applications and operation characteristics.

**Media**

Lecture with PowerPoint slides

**Literature**

Lecture Script, prepared by the lecturer. Obtainable at the Institut für Kolbenmaschinen

Recommended:

- Merker, Schwarz, Teichmann: Grundlagen Verbrennungsmotoren, Vieweg + Teubner Verlag 2011;
- Zacharias: Gasmotoren, Vogel Fachbuch 2001

**Course: Building- and Environmental Aerodynamics [19228]****Coordinators:** B. Ruck**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Graded: oral examination, 30 minutes

**Conditions**

none

**Recommendations**

Fluid mechanics, Hydromechanics

**Learning Outcomes**

The students are able to analyse and calculate steady and unsteady wind loading on technical and natural structures. They know the fundamentals of wind load assessment and flow induced vibrations as well as methods to estimate their influence. Typical applications will be demonstrated linking theory to practice.

**Content**

The lecture gives an introduction to the field of building- and environmental aerodynamics. Part 1 is dedicated to building aerodynamics and to the assessment of wind loads, whereas part 2 deals with aspects of flows in natural environments.

Topics: Atmospheric boundary layer and natural wind, Wind loads on technical and natural structures, Wind induced vibrations, Wind shelter, Wind tunnel modelling

## Course: Human brain and central nervous system: anatomy, information transfer, signal processing, neurophysiology and therapy [24139 / 24678]

**Coordinators:** U. Spetzger

**Part of the modules:** SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 3            | 2              | Winter / Summer Term | de                   |

### Learning Control / Examinations

The assessment is explained in the module description.

### Conditions

None.

### Recommendations

Prior attendance at lecture, seminars and laboratory in *Medical Simulation Systems* is recommended but not mandatory.

### Learning Outcomes

The students get an insight into neuromedicine and establish a general appreciation to the field of neuroinformatics. In particular, anatomy, information transfer, signal processing, neurophysiology and therapy are covered. Furthermore, the sensoric physiology, various malfunctions of the central nervous system, diagnostic procedures and different modern therapy modalities and treatment options are introduced.

### Content

The lecture wants to impart basic knowledge for students of computer sciences and bridges the information gap between engineering and medicine. The purpose is to describe the basis of the composition of the human brain with anatomical details of neural cells and nerve tissue. This represents the comprehension of the complex structure and the sequels within the human brain and spinal cord. It will improve the understanding of sensomotor-prostheses and artificial limbs and closely links to robotic systems. Furthermore, image-guided planning and computer-assisted surgical procedures in neurosurgery are demonstrated on different examples.

### Media

Slides or electronic files of the presentations

### Literature

Neuro- und Sinnesphysiologie Schmidt, Robert F.; Schaible, Hans-Georg (Hrsg.) 5. Auflage, 2006, Springer Verlag, ISBN: 978-3-540-25700-4 (9,95 Euro)

**Course: Appliance and Power Tool Design [2145164]****Coordinators:** S. Matthiesen**Part of the modules:** SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 min

Auxiliary means: none

Combined examination of lecture and project work.

**Conditions**

In Masters Course:

The participation in “Appliance and power tool design” requires the concurrent project work.

Due to organizational reasons, the number of participants is limited. At the beginning of August, a registration form will be available at the IPEK website. In the case of too many applicants, a selection process will be taking place.

An early application is advantageous.

**Recommendations**

CAE Workshop is recommended as elective course or complementary subject.

**Learning Outcomes**

The students are able to ...

- analyze complex and contradictory problems regarding the overall system user –machine and hence to create new solutions with focus on customer use.
- list, to identify and to explain strategies and approaches for the design of technical machines, to transfer them on new problems and to evaluate the working results concerning quality, costs and customer use.
- name the impact of specific boundary conditions, e.g. high quantities of mechatronic systems considering the customer, on the resulting design, to interpret the consequences and to evaluate the effects in unknown situations.
- name aspects of a successful product engineering in a team of worldwide acting companies regarding the field customer, company and market.
- evaluate their relevance for self-chosen examples and to transfer them on unknown problems.

**Content**

Operation system, system of objects and system of objectives of mechatronic appliances and power tool designs. Mode of operation as enabler of design, components of mechatronic systems, application oriented design, guidelines for appliance and power tool design.

Part of the lecture is a project work, in which theory will be reprocessed and presented in a practical way. In such exercises the students also will present their results developed in project teams.

The interaction of analysis and synthesis will be acquired in student teams at the example of different appliances and power tools.

**Remarks**

From summer term 2015 on the lecture take place in the summer term.

**Course: Global vehicle evaluation within virtual road test [2114850]****Coordinators:** B. Schick**Part of the modules:** SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: CarMaker Simulation Environment

**Conditions**

none

**Learning Outcomes**

The students have an overview of the vehicle dynamics simulation, the model parametrization and the related data sources. They have good knowledge about vehicle dynamics test methods and related execution of virtual test driving (open loop, closed loop). They are able to evaluate driving behavior based on self-created results. They have achieved knowledge about influences and interactions of components such as tires, suspension, kinematics and compliance, roll bars, steering, brakes, mass distribution and powertrain and they have the qualification to analyze, to judge and to optimize components with regard to global vehicle behavior.

**Content**

1. Testing and evaluation methods
2. Fundamentals of vehicle dynamics simulation
3. Execution of virtual test driving and evaluation of the results
4. Influence of several components and optimization of global driving behavior

**Literature**

1. Reimpell, J.: Fahrwerktechnik: Grundlagen, Vogel Verlag, 1995
2. Unrau, H.-J.: Skriptum zur Vorlesung "Fahreigenschaften I"
3. Unrau, H.-J.: Skriptum zur Vorlesung "Fahreigenschaften II"
4. IPG: User Guide CarMaker

**Course: Foundry Technology [2174575]****Coordinators:** C. Wilhelm**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

duration: 20 - 30 minutes

no notes

**Conditions**

Required: WK 1+2

**Learning Outcomes**

The students know the specific moulding and casting techniques and are able to describe them in detail. The students know the application of moulding and casting techniques concerning castings and metals, their advantages and disadvantages in comparison, their application limits and are able to describe these in detail.

The students know the applied metals and are able to describe advantages and disadvantages as well as the specific range of use.

The students are able, to describe detailed mould and core materials, technologies, their application focus and mould-affected casting defects.

The students know the basics of casting process of any casting parts concerning the above mentioned criteria and are able to describe detailed.

**Content**

Moulding and casting processes

Solidifying of melts

Castability

Fe-Alloys

Non-Fe-Alloys

Moulding and additive materials

Core production

Sand reclamation

Feeding technology

Design in casting technology

Casting simulation

Foundry Processes

**Literature**

Reference to literature, documentation and partial lecture notes given in lecture

## Course: Global Production and Logistics - Part 1: Global Production [2149610]

**Coordinators:** G. Lanza

**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The assessment is carried out as an oral exam. The examination date can be defined individually.

### Conditions

None

### Recommendations

Combination with Global Production and Logistics – Part 2

### Learning Outcomes

The students . . .

- can explain the general conditions and influencing factors of global production.
- are capable to apply defined procedures for site selection and to evaluate site decisions with the help of different methods.
- are able to select the adequate scope of design for site-appropriate production and product construction case-specifically.
- can state the central elements in the planning process of establishing a new production site.
- are capable to make use of the methods to design and scale global production networks for company-individual problems.
- are able to show up the challenges and potentials of the departments sales, procurement as well as research and development on global basis.

### Content

Target of the lecture is to depict the challenges and fields of action of global operating companies and to give an overview of central aspects in global production networks as well as establishing a deepening knowledge of established methods and procedures for design and scale. Within the course methods for site selection, procedures for site specific adjustment of product construction and product technology as well as planning approaches to establish a new production site are imparted. The course is rounded off by showing the characteristics of the departments sale, procurement as well as research and development under global aspects.

The topics are:

- Basic conditions and influencing factors of global production (historical development, targets, chances and threats)
- Global sales
- Site selection
- Site specific production adjustment
- Establishing of new production sites
- Global procurement
- Design and management of global production networks
- Global research and development

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

recommended secondary literature:

Abele, E. et al: Global Production – A Handbook for Strategy and Implementation, Springer 2008 (english)

**Remarks**

None

## Course: Global Production and Logistics - Part 2: Global Logistics [2149600]

**Coordinators:** K. Furmans

**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral / written (if necessary) => (see "Studienplan Maschinenbau", current version)

### Conditions

none

### Recommendations

We recommend the course "Logistics - organisation, design and control of logistic systems " (2118078) beforehand.

### Learning Outcomes

Students are able to:

- assign basic problems of planning and operation of global supply chains and plan them with appropriate methods,
- describe requirements and characteristics of global trade and transport, and
- evaluate characteristics of the design from logistic chains regarding their suitability.

### Content

Characteristics of global trade

- Incoterms
- Customs clearance, documents and export control

Global transport and shipping

- Maritime transport, esp. container handling
- Air transport

Modeling of supply chains

- SCOR model
- Value stream analysis

Location planning in cross-border-networks

- Application of the Warehouse Location Problem
- Transport Planning

Inventory Management in global supply chains

- Stock keeping policies

Inventory management considering lead time and shipping costs

### Media

presentations, black board

### Literature

#### Elective literature:

Master Program

Mechanical Engineering (M.Sc.)

Module Handbook, Date: 10/01/2014

- Arnold/Isermann/Kuhn/Tempelmeier. HandbuchLogistik, Springer Verlag, 2002 (Neuaufgabe in Arbeit)
- Domschke. Logistik, Rundreisen und Touren, Oldenbourg Verlag, 1982
- Domschke/Drexl. Logistik, Standorte, OldenbourgVerlag, 1996
- Gudehus. Logistik, Springer Verlag, 2007
- Neumann-Morlock. Operations-Research, Hanser-Verlag, 1993
- Tempelmeier. Bestandsmanagement in SupplyChains, Books on Demand 2006
- Schönsleben. IntegralesLogistikmanagement, Springer, 1998

**Remarks**

none

**Course: Size effects in micro and nanostructures materials [2181744]****Coordinators:** P. Gumbsch, D. Weygand, P. Gruber, M. Dienwiebel**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral exam 30 minutes

**Conditions**

compulsory preconditions: none

**Recommendations**

preliminary knowlegde in materials science

**Learning Outcomes**

The student can

- describe the mechanical behavior of nano and micrometer sized structured materials and analyse and explain the origin for the differences compared to classical materials behavior.
- explain processing routes, experimetal characterization methods and adequate modelling schems for nano- and microstructred maetriaals.

**Content**

Modern topics in the mechanics of materials are presented.

## 1. Nanotubes

\* production routes, properties

\* application

## 2. cermics

\* defect statistics

## 3. size effect in metallic structures

\* thin film mechanics

\* micro pillar

\* modelling:

discrete dislocation dynamic

## 4. nanocontact:

\* gecko

\* hierachical structures

## 5. nanotribology

\* contact, friction: simple and multiple contacts

\* radio nucleid technique

**Literature**

lecture slides

**Course: Fundamentals of Energy Technology [2130927]****Coordinators:** A. Badea**Part of the modules:** SP 15: Fundamentals of Energy Technology (p. [428](#))[SP\_15\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 5              | Summer term | de                   |

**Learning Control / Examinations****Conditions**

none

**Learning Outcomes**

The students will receive state of the art knowledge about the very challenging field of energy industry and the permanent competition between the economical profitability and the long-term sustainability.

**Content**

The following relevant fields of the energy industry are covered:

- Energy forms
- Thermodynamics relevant to energy industry
- Energy sources: fossil fuels, nuclear energy, renewable sources
- Energy industry in Germany, Europe and worldwide
- Power generation and environment
- Evaluation of energy conversion processes
- Thermal/electrical power plants and processes
- Transport of energy / energy carriers
- Energy storage
- Systems utilizing renewable energy sources
- Basics of economic efficiency and calculus / Optimisation
- Future of the energy industry

**Course: Automotive Engineering I [2113805]****Coordinators:** F. Gauterin, H. Unrau**Part of the modules:** (p. 475)[SP\_58\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term | de                   |

**Learning Control / Examinations**

Written examination

Duration: 120 minutes

Auxiliary means: none

**Conditions**

Can not be combined with lecture [2113809]

**Recommendations**

None.

**Learning Outcomes**

The students know the movements and the forces at the vehicle and are familiar with active and passive security. They have proper knowledge about operation of engines and alternative drives, the necessary transmission between engine and drive wheels and the power distribution. They have an overview of the components necessary for the drive and have the basic knowledge, to analyze, to judge and to develop the complex system "vehicle".

**Content**

1. History and future of the automobile
2. Driving mechanics: driving resistances and driving performances, mechanics of the longitudinal and transverse forces, collision mechanics
3. Engines: combustion engine, alternative drives (e.g. electric motor, fuel cell)
4. Transmission: clutches (e.g. friction clutch, visco clutch), transmission (e.g. mechanical transmission, hydraulic fluid transmission)
5. Power transmission and distribution: drive shafts, cardon joints, differentials

**Literature**

1. Mitschke, M./ Wallentowitz, H.: Dynamik der Kraftfahrzeuge, Springer-Verlag, Berlin, 2004
2. Braes, H.-H.; Seiffert, U.: Handbuch Kraftfahrzeugtechnik, Vieweg&Sohn Verlag, 2005
3. Gnadler, R.: Script to the lecture 'Automotive Engineering I'

**Course: Automotive Engineering II [2114835]****Coordinators:** F. Gauterin, H. Unrau**Part of the modules:** (p. 475)[SP\_58\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Written Examination

Duration: 90 minutes

Auxiliary means: none

**Conditions**

Can not be combined with lecture [2114855]

**Recommendations**

None.

**Learning Outcomes**

The students have an overview of the modules, which are necessary for the road holding of a motor vehicle and the power transmission between vehicle bodywork and roadway. They have knowledge of different wheel suspensions, the tyres, the steering elements and the brakes. They know different execution forms, the function and the influence on the driving or brake behavior. They are able to develop the appropriate components correctly. They are ready to analyze, to judge and to optimize the complex relationship of the different components under consideration of boundary conditions.

**Content**

1. Chassis: Wheel suspensions (rear axles, front axles, kinematics of axles), tyres, springs, damping devices
2. Steering elements: Steering elements of single vehicles and of trailers
3. Brakes: Disc brake, drum brake, retarder, comparison of the designs

**Literature**

1. Heißing, B./Ersoy, M.: Fahrwerkhandbuch: Grundlagen, Fahrdynamik, Komponenten, Systeme, Mechatronik, Perspektiven, Vieweg-Verlag, Wiesbaden, 2011
2. Breuer, B./Bill, K.-H.: Bremsenhandbuch: Grundlagen - Komponenten - Systeme - Fahrdynamik, Vieweg-Verlag, Wiesbaden, 2012
3. Gnadler, R.: Script to the lecture 'Automotive Engineering II'

## Course: Grundlagen der Herstellungsverfahren der Keramik und Pulvermetallurgie [2193010]

**Coordinators:** R. Oberacker

**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 43: Technical Ceramics and Powder Materials (p. 462)[SP\_43\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The assessment consists of an oral exam (20-30 min) taking place at the agreed date. The re-examination is offered upon agreement.

### Conditions

None.

### Recommendations

Knowledge of basic material science is assumed

### Learning Outcomes

The students know the basics of characterization of powders, pastes and suspensions. They have a fundamental understanding of the process technology for shaping of particulate systems. They are able to use these fundamentals to design selected wet- and dry forming processes.

### Content

The course covers fundamentals of the process technology for shaping of ceramic or metal particle systems. Important shaping methods are reviewed. The focus is on characterization and properties of particulate systems, and, in particular, on process technology for shaping of powders, pastes, and suspensions.

### Literature

- R.J. Brook: Processing of Ceramics I+II, VCH Weinheim, 1996
- M.N. Rahaman: Ceramic Processing and Sintering, 2nd Ed., Marcel Dekker, 2003
- W. Schatt ; K.-P. Wieters ; B. Kieback. „Pulvermetallurgie: Technologien und Werkstoffe“, Springer, 2007
- R.M. German. “Powder metallurgy and particulate materials processing. Metal Powder Industries Federation, 2005
- F. Thümmeler, R. Oberacker. “Introduction to Powder Metallurgy”, Institute of Materials, 1993

**Course: Fundamentals of catalytic exhaust gas aftertreatment [2134138]****Coordinators:** E. Lox**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], (p. 475)[SP\_58\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination, Duration: 25 min., no auxiliary means

**Conditions**

none

**Recommendations**

Fundamentals of Combustion engines I helpful

**Learning Outcomes**

The students can name and explain the scientific fundamentals of the catalytic exhaust gas aftertreatment, as well as the technical, political and economical parameters of its application in engines for passenger cars and HD vehicles.

The students are able to point out and explain which emissions are formed in combustion engines, why these emissions are health-related critical and which measures the legislator has established to reduce the emissions.

**Content**

1. kind and source of emissions
2. emission legislation
3. principal of catalytic exhaust gas aftertreatment (EGA)
4. EGA at stoichiometric gasoline engines
5. EGA at gasoline engines with lean mixtures
6. EGA at diesel engines
7. economical basic conditions for catalytic EGA

**Literature**

Lecture notes available in the lectures

1. "Environmental Catalysis" Edited by G.Ertl, H. Knötzinger, J. Weitkamp Wiley-VCH Verlag GmbH, Weinheim, 1999 ISBN 3-527-29827-4
2. "Cleaner Cars- the history and technology of emission control since the 1960s" J. R. Mondt Society of Automotive Engineers, Inc., USA, 2000 Publication R-226, ISBN 0-7680-0222-2
3. "Catalytic Air Pollution Control - commercial technology" R. M. Heck, R. J. Farrauto John Wiley & Sons, Inc., USA, 1995 ISBN 0-471-28614-1
4. "Automobiles and Pollution" P. Degobert Editions Technic, Paris, 1995 ISBN 2-7108-0676-2
5. "Reduced Emissions and Fuel Consumption in Automobile Engines" F. Schaefer, R. van Basshuysen, Springer Verlag Wien New York, 1995 ISBN 3-211-82718-8
6. "Autoabgaskatalysatoren : Grundlagen - Herstellung - Entwicklung - Recycling - Ökologie" Ch. Hagelüken und 11 Mitautoren, Expert Verlag, Renningen, 2001 ISBN 3-8169-1932-4

**Course: Principles of Medicine for Engineers [2105992]****Coordinators:** C. Pylatiuk**Part of the modules:** SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral, also possible as an optional or part of a major subject

**Conditions**

None.

**Recommendations**

Organ support systems

**Learning Outcomes**

Students have fundamental knowledge about functionality and anatomy of organs within different medical disciplines. The students further know about technical methods in diagnosis and therapy, common diseases, their relevance and costs. Finally the students are able to communicate with medical doctors in a way, in which they prevent misunderstandings and achieve a more realistic idea of each others expectations.

**Content**

- Introduction: Definitions of “health” and “disease”. History of medicine and paradigm shift towards evidence based medicine and personalized medicine.
- Special topics: nervous system, saltatory conduction, musculoskeletal system, cardio-circulatory system, narcosis, pain, respiratory system, sensory organs, gynaecology, digestive organs, surgery, nephrology, orthopaedics, immune system, genetics.

**Literature**

- Adolf Faller, Michael Schünke: Der Körper des Menschen. Thieme Verlag.
- Renate Huch, Klaus D. Jürgens: Mensch Körper Krankheit. Elsevier Verlag.

**Course: Introduction to Microsystem Technology I [2141861]****Coordinators:** A. Guber**Part of the modules:** SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes**

The lecture gives an introduction into the basics of microsystems technology. In analogy to processes employed in fabrication of microelectronics circuits the core technologies as well as materials for producing microstructures and components are presented. Finally, various techniques for Silicon micromachining are explained and illustrated with examples for micro-components and micro-systems.

**Content**

- Introduction in Nano- and Microtechnologies
- Silicon and processes for fabricating microelectronics circuits
- Basic physics background and crystal structure
- Materials for micromachining
- Processing technologies for microfabrication
- Silicon micromachining
- Examples

**Literature**

M. Madou

Fundamentals of Microfabrication

Taylor &amp; Francis Ltd.; Auflage: 3. Auflage. 2011

**Course: Introduction to Microsystem Technology II [2142874]****Coordinators:** A. Guber**Part of the modules:** SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes**

The lecture gives an introduction into the basics of microsystems technology. In the first part, methods for lithographic pattern transfer are summarized. Then specific techniques such as the LIGA process, micro-machining, and laser-patterning are explained and examples are given. Finally assembly and packaging methods are presented leading into a discussion of entire microsystems.

**Content**

- Introduction in Nano- and Microtechnologies
- Lithography
- LIGA-technique
- Mechanical microfabrication
- Patterning with lasers
- Assembly and packaging
- Microsystems

**Literature**

M. Madou

Fundamentals of Microfabrication

Taylor &amp; Francis Ltd.; Auflage: 3. Auflage. 2011

**Course: Foundations of nonlinear continuum mechanics [2181720]****Coordinators:** M. Kamlah**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral exam 30 minutes

**Conditions**

Engineering Mechanics - Advanced Mathematics

**Learning Outcomes**

The students understand the fundamental structure of a continuum theory consisting of kinematics, balance laws and constitutive model. In particular, they recognize non-linear continuum mechanics as a common structure including all continuum theories of thermomechanics, which are obtained by adding a corresponding constitutive model. The students understand in detail the kinematics of finite deformation and know the transition to the geometrically linear theory they are familiar with. The students know the spatial and material representation of the theory and the different related tensors. The students take the balance laws as physical postulates and understand their respective physical motivation.

**Content**

The lecture is organized in three parts. In the first part, the mathematical foundations of tensor algebra and tensor analysis are introduced, usually in cartesian representation. In the second part of the lecture, the kinematics, i.e. the geometry of deformation is presented. Besides finite deformation, geometric linearization is discussed. The third part of the lecture deals with the physical balance laws of thermomechanics. It is shown, how a special classical theory of continuum mechanics can be derived by adding a corresponding constitutive model. For the illustration of the theory, elementary examples are discussed repeatedly.

**Literature**

lecture notes

## Course: Fundamentals of reactor safety for the operation and dismantling of nuclear power plants [2190465]

**Coordinators:** V. Sánchez-Espinoza

**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

### Learning Control / Examinations

**oral examination**; duration: 20-30 minutes

### Conditions

Nuclear Safety I: Fundamentals, Nuclear power plants, Nuclear thermal hydraulics

### Recommendations

none

### Learning Outcomes

- gain understanding for safety analysis and its methods
- get familiar with the mathematical-physical basis of numerical safety analysis codes used for the safety demonstration as well as with the role of code validation
- get familiar with the methodology to analyse design basis accidents of Light Water Reactors and with the step-by-step of the modelling of nuclear power plants with simulation tools

### Content

The goal of this lecture is to impart the main elements and newest methods applied in the industry and by regulators that are needed to perform a safety assessment of nuclear power plants of generation 2 and 3 using numerical simulation tools. This lecture is focused on the deterministic safety analysis methodology; the mathematical and physical bases of numerical simulation tools used for safety demonstration and last but not least the safety criteria. The methodology and the prediction capability of Safety Analysis Tools (TRACE/PARCS, RELAP5/PARCS) widely used in industry, regulators and R&D institutions is exemplary demonstrated by analyzing selected transients and accidents of Light Water Reactors (LWR). The examples will describe the practical steps developing integral nuclear power plant models for the analysis of the normal and off-normal operation conditions. This lecture will be concentrated on the following topics:

- Safety analysis- an introduction
- Mathematical-physical basis of coupled neutronic-thermal hydraulic Best-Estimate codes
- Characterization of the plant conditions (start-up, operation, shutdown)
- Design basis accidents
- Methodologies for the accident analysis of Pressurized and Boiling Water Reactors (PWR, BWR)
- Analysis of selected transients and accidents of PWR and BWR (RIA, LOCA, MSLB, TUSA)
- Beyond design basis accidents (physical phenomena and simulation tools)

**Course: Fundamentals of X-ray Optics I [2141007]****Coordinators:** A. Last**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

**Conditions**

basics in optics

**Recommendations**

This lecture addresses to students in mechanical engineering and physics interested in X-ray optics.

additional lecture: accelerator physics I/II (2208111)

<http://www.imt.kit.edu/113.php>**Learning Outcomes**

The lecture will enable the students to judge capabilities of different X-ray optical imaging methods and instrumentation and to select suitable methods for a given task.

**Content**

The lecture covers general principles of optics as well as basics, functioning and application of reflective, refractive and diffractive X-ray optical elements and systems. Selected X-ray analytical imaging methods and the necessary optical elements are discussed including their potentials and limitations.

**Literature**

M. Born und E. Wolf

Principles of Optics, 7th (expanded) edition

Cambridge University Press, 2010

A. Erko, M. Idir, T. Krist und A. G. Michette

Modern Developments in X-Ray and Neutron Optics

Springer Series in Optical Sciences, Vol. 137

Springer-Verlag Berlin Heidelberg, 2008

D. Attwood

Soft X-Rays and Extreme Ultraviolet Radiation: Principles and Applications

Cambridge University Press, 1999

**Remarks**

Lecture dates will be fixed in agreement with the students, see institutes website.

A visit at synchrotron ANKA is possible if requested.

**Course: Basics of Technical Logistics [2117095]****Coordinators:** M. Mittwollen, Madzharov**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations**

after each lesson period; oral / written (if necessary) =&gt; (look at "Studienplan Maschinenbau", latest version)

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Students are able to:

- Describe processes and machines of technical logistics,
- Model the fundamental structures and the impacts of material handling machines with mathematical models,
- Refer to industrially used machines and
- Model real machines applying knowledge from lessons and calculate their dimensions.

**Content**

Bases effect model of conveyor machines made for the change of position and orientation; conveyor processes; identification systems; drives; mechanical behaviour of conveyors; structure and function of conveyor machines; elements of intralogistics

sample applications and calculations in addition to the lectures inside practical lectures

**Media**

supplementary sheets, projector, blackboard

**Literature**

Recommendations during lessons

**Course: Fundamentals of Combustion I [2165515]****Coordinators:** U. Maas**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Compulsory elective subject: Written exam.  
 In SP 45: oral exam.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

After completing this course students are able to:

- explain the chemical and physical processes governing combustion.
- discuss diagnostic methods applied in combustion science.
- describe laminar and turbulent flames in a mathematical way.
- analyse the working principle of various technical combustion systems (e. g. piston engines, gas turbines, furnaces).

**Content**

Fundamental concepts and phenomena  
 Experimental analysis of flames  
 Conservation equations for laminar flat flames  
 Thermodynamics of combustion processes  
 Transport phenomena  
 Chemical reactions  
 Chemical kinetics mechanisms  
 Laminar premixed flames  
 Laminar diffusion flames

**Media**

Blackboard and Powerpoint presentation

**Literature**

Lecture notes,  
 Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation,  
 authors: U. Maas, J. Warnatz, R.W. Dibble, Springer-Lehrbuch, Heidelberg 1996

**Remarks**

Compulsory elective subject: 2+1 SWS and 5 LP.

**Course: Fundamentals of combustion II [2166538]****Coordinators:** U. Maas**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], (p. 475)[SP\_58\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

After completing the course attendents are able to:

- explain the processes involved in ignition (auto-ignition and induced ignition).
- describe the governing mechanisms in combustion of liquid and solid fuels.
- understand the mechanisms governing pollutant formation.
- describe turbulent reacting flows by means of simple models.
- explain the occurrence of engine knock.
- outline the basic numerical schemes applied in the simulation of reacting flows.

**Content**

Ignition processes

Three dimensional Navier-Stokes equations for reacting flows

Tubulent reactive flows

Turbulent non-premixed flames

Turbulent premixed flames

Combustion of liquid and solid fuels

Engine knock

NOx formation

Formation of hydrocarbons and soot

**Media**

Blackboard and Powerpoint presentation

**Literature**

Lecture notes;

Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation;  
Authors: U. Maas, J. Warnatz, R.W. Dibble, Springer; Heidelberg, Karlsruhe, Berkley 2006

**Course: Fundamentals of Combustion Engines I [2133103]****Coordinators:** H. Kubach, T. Koch**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], (p. 475)[SP\_58\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

**Learning Control / Examinations**

oral examination, Duration: 25 min., no auxiliary means

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The student can name and explain the working principle of combustion engines. He is able to analyse and evaluate the combustion process. He is able to evaluate influences of gas exchange, mixture formation, fuels and exhaust gas aftertreatment on the combustion performance. He can solve basic research problems in the field of engine development.

**Content**

Introduction, History, Concepts  
 Working Principle and Thermodynamics  
 Characteristic Parameters  
 Air Path  
 Fuel Path  
 Energy Conversion  
 Fuels  
 Emissions  
 Exhaust Gas Aftertreatment

**Course: Fundamentals of Combustion Engines II [2134131]****Coordinators:** H. Kubach, T. Koch**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach], (p. 475)[SP\_58\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

oral examination, duration: 25 minutes, no auxiliary means

**Conditions**

None.

**Recommendations**

Fundamentals of Combustion Engines I helpful

**Learning Outcomes**

The students deepen and complement their knowledge from the lecture combustion engines A. they can name and explain construction elements, development tools and latest development trends. They are able to analyse and evaluate powertrain concepts which are subject of the lecture.

**Content**

Emissions

Fuels

Drive Train Dynamics

Engine Parts

Boosting

Alternative Powertrain Concepts

Special Engine Concepts

Power Transmission

**Course: Optical Flow Measurement: Fundamentals and Applications [2153410]****Coordinators:** F. Seiler**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

no auxiliary means

**Conditions**

none

**Learning Outcomes**

The students can thoroughly describe the introduced optical measurement techniques. From recently achieved results in shock tunnels, they are able to explain the working principle(s) of the most important registration and visualization methods working with either tracer scattering or with the information obtained with light passing directly through the measuring regime. Particularly, the students are qualified to comparatively discuss the measurement techniques for velocity, density and gas temperature (listed below) and can furthermore illustrate their working principles with examples:

- shadowgraph techniques
- Schlieren method
- Mach/Zehnder- and Differential interferometer
- Particle Image Velocimetry (PIV)
- Doppler Global Velocimetry (DGV)
- Doppler picture velocimetry (DPV)
- classical single-beam
- cross-beam anemometry
- interference velocimetry
- CARS-method
- laser-induced fluorescence (LIF)

**Content**

- Visualisations techniques
- Techniques for local point-wise measurement
- Techniques using light scattering methods
- Laser-induced fluorescence

**Literature**

H. Oertel sen., H. Oertel jun.: Optische Strömungsmeßtechnik, G. Braun, Karlsruhe

F. Seiler: Skript zur Vorlesung über Optische Strömungsmeßtechnik

**Course: Fundamentals for Design of Motor-Vehicles Bodies I [2113814]****Coordinators:** H. Bardehle**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Winter term | de                   |

**Learning Control / Examinations**

Oral group examination

Duration: 30 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students have an overview of the fundamental possibilities for design and manufacture of motor-vehicle bodies. They know the complete process, from the first idea, through the concept to the dimensioned drawings (e.g. with FE-methods). They have knowledge about the fundamentals and their correlations, to be able to analyze and to judge relating components as well as to develop them accordingly.

**Content**

1. History and design
2. Aerodynamics
3. Design methods (CAD/CAM, FEM)
4. Manufacturing methods of body parts
5. Fastening technologie
6. Body in white / body production, body surface

**Literature**

1. Automobiltechnische Zeitschrift ATZ, Friedr. Vieweg & Sohn Verlagsges. mbH, Wiesbaden
2. Automobil Revue, Bern (Schweiz)
3. Automobil Produktion, Verlag Moderne Industrie, Landsberg

**Course: Fundamentals for Design of Motor-Vehicles Bodies II [2114840]****Coordinators:** H. Bardehle**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Summer term | de                   |

**Learning Control / Examinations**

Oral group examination

Duration: 30 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students know that, often the design of seemingly simple detail components can result in the solution of complex problems. They have knowledge in testing procedures of body properties. They have an overview of body parts such as bumpers, window lift mechanism and seats. They understand, as well as, parallel to the normal electrical system, about the electronic side of a motor vehicle. Based on this they are ready to analyze and to judge the relation of these single components. They are also able to contribute competently to complex development tasks by imparted knowledge in project management.

**Content**

1. Body properties/testing procedures
2. External body-parts
3. Interior trim
4. Compartment air conditioning
5. Electric and electronic features
6. Crash tests
7. Project management aspects, future prospects

**Literature**

1. Automobiltechnische Zeitschrift ATZ, Friedr. Vieweg & Sohn Verlagsges. mbH, Wiesbaden
2. Automobil Revue, Bern (Schweiz)
3. Automobil Produktion, Verlag Moderne Industrie, Landsberg

**Course: Fundamentals in the Development of Commercial Vehicles I [2113812]****Coordinators:** J. Zürn**Part of the modules:** SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Winter term | de                   |

**Learning Control / Examinations**

Oral group examination

Duration: 30 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students have proper knowledge about the process of commercial vehicle development starting from the concept and the underlying original idea to the real design. They know that the customer requirements, the technical realisability, the functionality and the economy are important drivers.

The students are able to develop parts and components. Furthermore they have knowledge about different cab concepts, the interior and the interior design process. Consequently they are ready to analyze and to judge concepts of commercial vehicles as well as to participate competently in the commercial vehicle development.

**Content**

1. Introduction, definitions, history
2. Development tools
3. Complete vehicle
4. Cab, bodyshell work
5. Cab, interior fitting
6. Alternative drive systems
7. Drive train
8. Drive system diesel engine
9. Intercooled diesel engines

**Literature**

1. Marwitz, H., Zittel, S.: ACTROS – die neue schwere Lastwagenbaureihe von Mercedes-Benz, ATZ 98, 1996, Nr. 9
2. Alber, P., McKellip, S.: ACTROS – Optimierte passive Sicherheit, ATZ 98, 1996
3. Morschheuser, K.: Airbag im Rahmenfahrzeug, ATZ 97, 1995, S. 450 ff.

**Course: Fundamentals in the Development of Commercial Vehicles II [2114844]****Coordinators:** J. Zürn**Part of the modules:** SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Summer term | de                   |

**Learning Control / Examinations**

Oral group examination

Duration: 30 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students know the advantages and disadvantages of different drives. Furthermore they are familiar with components, such as transfer box, propeller shaft, powered and non-powered frontaxle etc. Beside other mechanical components, such as chassis, axle suspension and braking system, also electric and electronic systems are known. Consequently the student are able to analyze and to judge the general concepts as well as to adjust them precisely with the area of application.

**Content**

1. Gear boxes of commercial vehicles
2. Intermediate elements of the drive train
3. Axle systems
4. Front axles and driving dynamics
5. Chassis and axle suspension
6. Braking System
7. Systems
8. Excursion

**Literature**

1. Schittler, M., Heinrich, R., Kerschbaum, W.: Mercedes-Benz Baureihe 500 – neue V-Motorengeneration für schwere Nutzfahrzeuge, MTZ 57 Nr. 9, S. 460 ff., 1996
2. Robert Bosch GmbH (Hrsg.): Bremsanlagen für Kraftfahrzeuge, VDI-Verlag, Düsseldorf, 1. Auflage, 1994
3. Rubi, V., Striffler, P. (Hrsg. Institut für Kraftfahrwesen RWTH Aachen): Industrielle Nutzfahrzeugentwicklung, Schriftenreihe Automobiltechnik, 1993

**Course: Fundamentals of Automobile Development I [2113810]****Coordinators:** R. Frech**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Winter term | de                   |

**Learning Control / Examinations**

Written examination

Duration: 90 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students have an overview of the fundamentals of the development of automobiles. They know the development process, the national and the international legal requirements that are to be met. They have knowledge about the thermo-management, aerodynamics and the design of an automobile. They are ready to judge goal conflicts in the field of automobile development and to work out approaches to solving a problem.

**Content**

1. Process of automobile development
2. Conceptual dimensioning and design of an automobile
3. Laws and regulations – National and international boundary conditions
4. Aero dynamical dimensioning and design of an automobile I
5. Aero dynamical dimensioning and design of an automobile II
6. Thermo-management in the conflict of objectives between styling, aerodynamic and packaging guidelines I
7. Thermo-management in the conflict of objectives between styling, aerodynamic and packaging guidelines II

**Literature**

The scriptum will be provided during the first lessons

**Course: Fundamentals of Automobile Development II [2114842]****Coordinators:** R. Frech**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Summer term | de                   |

**Learning Control / Examinations**

Written examination

Duration: 90 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students are familiar with the selection of appropriate materials and the choice of adequate production technology. They have knowledge of the acoustical properties of the automobiles, covering both the interior sound and exterior noise. They have an overview of the testing procedures of the automobiles. They know in detail the evaluation of the properties of the complete automobile. They are ready to participate competently in the development process of the complete vehicle.

**Content**

1. Application-oriented material and production technology I
2. Application-oriented material and production technology II
3. Overall vehicle acoustics in the automobile development
4. Drive train acoustics in the automobile development
5. Testing of the complete vehicle
6. Properties of the complete automobile

**Literature**

The scriptum will be provided during the first lessons.

**Course: High Performance Computing [2183721]****Coordinators:** B. Nestler, M. Selzer**Part of the modules:** SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Winter term | de                   |

**Learning Control / Examinations**

We regularly discuss exercises at the computer.

At the end of the semester, there will be a written exam.

**Conditions**

None.

**Recommendations**

preliminary knowledge in mathematics, physics and materials science

**Learning Outcomes**

The student

- can explain the foundations and strategies of parallel programming
- can efficiently apply high performance computers for simulations by elaborating respective parallelisation techniques.
- has an overview of typical applications and the specific requirements for parallelization.
- knows the concepts of parallelisation and is capable to apply these to efficiently use high performance computing resources and the growing performance of multi core processors in science and industry.
- has experiences in programming of parallel algorithms through integrated computer exercises.

**Content**

Topics of the high performance computing course are:

- architectures of parallel platforms
- parallel programming models
- performance analysis of concurrent programs
- parallelization models
- MPI and OpenMP
- monte-Carlo method
- 1D & 2D heat diffusion
- raycasting
- n-body problem
- simple phase-field models

**Media**

Slides of the lecture, exercise sheets, solution files of the computer exercises.

**Literature**

1. Lecture Notes; Problem Sheets; Program templates
2. Foundations of Multithreaded, Parallel, and Distributed Programming, Gregory R. Andrews; Addison Wesley 2000

**Course: High Temperature Structural Materials [2174600]****Coordinators:** M. Heilmaier**Part of the modules:** SP 56: Advanced Materials Modelling (p. 474)[SP\_56\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral, 30min.

**Conditions**

Relevant Bachelor degree

**Recommendations**

None

**Learning Outcomes**

Students are able to

- Define properly the term „high temperature“ with respect to materials
- Describe the shape of the creep curve based on underlying deformation mechanisms
- Rationalize the influence of relevant parameters such as temperature, stress, microstructure on the high temperature deformation behavior
- Develop strategies for improving creep resistance of alloys via modifying their composition
- Select properly industrially relevant high temperature structural materials for various applications

**Content**

- Phenomenology of High Temperature Deformation
- Deformation Mechanisms
- High Temperature Structural Materials

**Literature**

M.E. Kassner, Fundamentals of Creep in Metals and Alloys, Elsevier, Amsterdam, 2009

## Course: Advanced Methods in Strength of Materials [2161252]

**Coordinators:** T. Böhlke

**Part of the modules:** SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 4              | Winter term | de                   |

### Learning Control / Examinations

depending on choice according to actual version of study regulations

Additives as announced

Prerequisites have to be met by attestations during the associated lab course

### Conditions

The institutes decides about registration for the lab course (restricted number of participants).

### Recommendations

None.

### Learning Outcomes

The students can

- perform basic tensor operations
- apply solution concepts of elasticity theory to sample problems
- analyse and evaluate systems within the framework of linear elastic fracture mechanics
- know elements of elasto-plasticity theory
- evaluate systems according to known flow and failure hypotheses
- apply concepts of elasto-plasticity to sample problems
- solve independently small problems about topics of lecture during the corresponding lab course using the FE-software ABAQUS

### Content

- kinematics
- mechanical balance laws
- theory of elasticity
- linear elastic fracture mechanics
- linear and plane structures
- elasto-plasticity theory

### Literature

lecture notes

Gummert, P.; Reckling, K.-A.: Mechanik. Vieweg 1994.

Gross, D.; Seelig, T.: Bruchmechanik. Springer 2002.

Hibbeler, R.C.: Technische Mechanik 2 - Festigkeitslehre. Pearson Studium 2005.

## Course: Hybrid and Electric Vehicles [23321]

**Coordinators:** M. Doppelbauer, M. Schiefer

**Part of the modules:** SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

### Learning Control / Examinations

written exam (2 h)

### Conditions

none

### Recommendations

none

### Learning Outcomes

The students are able to understand the technical functionality of all drive components of hybrid and electric vehicles and their interaction in the drive train. They possess detailed knowledge about all drive components, in particular batteries and fuel cells, power electronics and electric machines including gears. Moreover they know the different drive train topologies and their specific advantages and disadvantages. The students can evaluate the technical, economical and ecological impact of alternative automotive drive technologies.

### Content

Starting with the mobility needs of the modern industrialized society and the political goals concerning climate protection, the different drive and charge concepts of battery-electric and hybrid-electric vehicles are introduced and evaluated. The lecture gives a wide overview on all needed components such as electric drive trains, especially batteries, chargers, DC/DC-converters, DC/AC-converters, electrical machines and gear drives.

Structure:

- Hybrid automotive drive trains
- Electric automotive drive trains
- Driving resistance and energy consumption
- Control strategies
- Energy storage systems
- Fundamentals of electric machines
- Induction machines
- Synchronous machines
- Special machines
- Power electronics
- Charging
- Environment
- Automotive examples
- Requirements and specifications

### Media

Slides

### Literature

- 
- Peter Hofmann: Hybridfahrzeuge – Ein alternatives Antriebskonzept für die Zukunft, Springer-Verlag, 2010
- L. Guzzella, A. Sciarretta: Vehicle Propulsion Systems – Introduction to Modeling and Optimization, Springer Verlag, 2010
- Konrad Reif: Konventioneller Antriebsstrang und Hybridantriebe – Bosch Fachinformation Automobil, Vieweg+Teubner Verlag, 2010
- Rolf Fischer: Elektrische Maschinen, Carl Hanser Verlag München, 2009

- Joachim Specovius: Grundkurs Leistungselektronik, Vieweg+Teubner Verlag, 2010

**Remarks**

The lecture slides can be downloaded from the institute's homepage at the beginning of the semester. Due to organizational reasons a certificate of attendance cannot be issued.

**Course: Hydraulic Fluid Machinery I (Basics) [2157432]****Coordinators:** M. Gabi**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term | de                   |

**Learning Control / Examinations**

Oral or written examination (see announcement)

No tools or reference materials may be used during the exam.

**Conditions**

2157432 (Hydraulic Machinery) can not be combined with the event 2157451 (Wind and Hydropower)

**Recommendations**

2153412 Fluid mechanics

**Learning Outcomes**

Students get to know the basics of hydraulic fluid machinery (pumps, fans, hydroturbines, windturbines, hydrodynamic transmissions) in general. Application of the knowledge in different fields of engineering.

The lecture introduces the basics of Hydraulic Fluid Machinery. The different types and shapes are presented. The basic equations for the preservation of mass, momentum and energy are discussed. Velocity schemes in typical cascades are shown, the Euler equation of fluid machinery and performance characteristics are deduced.

Similarities and dimensionless parameters are discussed. Fundamental aspects of operation and cavitation are shown.

Students are able to understand the working principle of Hydraulic Fluid Machinery as well as the interaction with typical systems, in which they are integrated.

**Content**

1. Introduction
2. Basic equations
3. System analysis
4. Elementary Theory (Euler's equation of Fluid Machinery)
5. Operation and Performance Characteristics
6. Similarities, Specific Values
7. Control technics
8. Wind Turbines, Propellers
9. Cavitation
10. Hydrodynamic transmissions and converters

**Literature**

1. Fister, W.: Fluidenergiemaschinen I & II, Springer-Verlag
2. Bohl, W.: Strömungsmaschinen I & II . Vogel-Verlag
3. Gülich, J.F.: Kreiselpumpen, Springer-Verlag
4. Pfleiderer, C.: Die Kreiselpumpen. Springer-Verlag
5. Carolus, T.: Ventilatoren. Teubner-Verlag
6. Kreiselpumpenlexikon. KSB Aktiengesellschaft
7. Zierep, J., Bühler, K.: Grundzüge der Strömungslehre. Teubner-Verlag

**Course: Hydraulic Fluid Machinery II [2158105]****Coordinators:** S. Caglar, M. Gabi**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: ca. 30 minutes

No tools or reference materials may be used during the exam.

**Conditions**

Hydraulic Fluid Machinery I (Basics)

**Recommendations**

2153412 Fluid mechanics

**Learning Outcomes**

Students get to know advanced basics of hydraulic fluid machinery (pumps, fans, hydroturbines, windturbines, hydrodynamic transmissions). Application of the knowledge in different fields of engineering.

The lecture introduces, based on the lecture Hydraulic Fluid Machinery I, advanced knowledge in the field of design and operation. The different types and shapes are discussed.

Students are able to understand the working and design principle of Hydraulic Fluid Machinery as well as the interaction with typical systems, in which they are integrated.

**Content**

Rotodynamic pumps and fans of different types of construction

Hydro turbines

Wind turbines

Hydrodynamic transmissions

**Literature**

1. Fister, W.: Fluidenergiemaschinen I & II, Springer-Verlag
2. Siegloch, H.: Strömungsmaschinen, Hanser-Verlag
3. Pfeleiderer, C.: Kreiselpumpen, Springer-Verlag
4. Carolus, T.: Ventilatoren, Teubner-Verlag
5. Bohl, W.: Ventilatoren, Vogel-Verlag
6. Raabe, J.: Hydraulische Maschinen, VDI-Verlag
7. Wolf, M.: Strömungskupplungen, Springer-Verlag
8. Hau, E.: Windkraftanlagen, Springer-Verlag

**Course: Hydrodynamic Stability: From Order to Chaos [2154437]****Coordinators:** A. Class**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 minutes

Auxiliary means: none

**Conditions**

Mathematics

**Learning Outcomes**

The students can apply the analytic and numerical methods for an evaluation of stability properties of hydrodynamic systems. They are qualified to discuss the characteristic influence of parameter changes (e.g. Reynolds number) on the calculated results with respect to the flow character and properties (e.g. transition laminar/turbulent flow).

**Content**

Increasing a control parameter of a thermohydraulic system, e.g. the Reynolds number, the initial flow pattern (e.g. stationary flow) can be replaced by a different pattern (e.g. turbulent flow).

Typical hydrodynamic instabilities are summarized in the lecture.

The systematic analysis of thermohydraulic stability problems is developed for the case of Rayleigh-Bernard convection (fluid layer heated from below) and selected examples from fluid dynamics.

Covered is:

- linear stability analysis: determine limiting control parameter value up to which the basic flow pattern is stable against small perturbations.
- nonlinear reduced order modeling, capable to characterize more complex flow patterns
- Lorenz system: a generic system exhibiting chaotic behavior

**Media**

Black board

**Literature**

Script

**Remarks**

Lecture also offered as a block-lecture within the AREVA Nuclear Professional School ([www.anps.kit.edu](http://www.anps.kit.edu))

**Course: Industrial aerodynamics [2153425]****Coordinators:** T. Breitling**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

no auxiliary means

**Conditions**

None.

**Learning Outcomes**

Students can describe the different challenges of aerodynamical flow that occur in vehicles. They are qualified to analyze external flows around the vehicles, flows in the passenger compartments (thermal comfort), as well as cooling flows, charge motion, mixing and combustion processes in the engine.

**Content**

This compact lecture deals with flow, mixing and combustion phenomena with significance in vehicle development. A special focus is set on the optimization of external car and truck aerodynamics, thermal comfort in passenger compartments, analyses of cooling flows and improvement of charge motion, mixing and combustion in piston engines. These fields are explained in their phenomenology, the corresponding theories are discussed and the tools for measurement and simulation are introduced and demonstrated. The focus of this lecture is on industry relevant methods for analyses and description of forces, flow structures, turbulence, flows with heat transfer and phase transition and reactive flows. In addition an introduction to modern methods in accuracy control and efficiency improvement of numerical methods for industrial use is given. The integration and interconnection of the methods in the development processes are discussed exemplary.

An excursion to the Daimler AG wind tunnel and the research and development centers is planned.

- Industrial flow measurement techniques
- Flow simulation and control of numerical errors, turbulence modeling
- Cooling flows
- Flow mixing and combustion at direct injected Diesel engines
- Flow mixing and combustion at gasoline engine
- Vehicle aerodynamics
- HVAC-Systems and thermal comfort
- Aeroacoustics

**Literature**

Script

**Remarks**

Block course with limited number of participants, registration in the secretary's office required. See details at [www.istm.kit.edu](http://www.istm.kit.edu)

## Course: Introduction to Industrial Production Economics [2109042]

**Coordinators:** S. Dürrschnabel

**Part of the modules:** SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach], SP 37: Production Management (p. 455)[SP\_37\_mach], SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

### Conditions

Registration for the lecture via ILIAS necessary.

### Learning Outcomes

- The students know the possible organisational structures for enterprises.
- The students learn about the importance of process data as basis for efficient work structuring.
- The students are able to execute and evaluate time studies in industry (e.g. REFA).
- The students know different methods for the evaluation of working places.
- The students know basic techniques for the determination of wages.
- The students are able to make a cost calculation for a specific product.

### Content

- Configuration of the departmental organisation and the process organisation
- Execution and evaluation of time studies
- Actual tools for time studies, e.g. Work Sampling, Methods-Time Measurement, Planned times,
- Evaluation of workplaces and determination of wages
- Cost accounting (including Process costs)

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- REFA – Verband für Arbeitsstudien und Betriebsorganisation (Hrsg.): Ausgewählte Methoden zur prozessorientierten Arbeitsorganisation. Darmstadt: REFA, 2002.
- SCHLICK, Christopher; BRUDER, Ralph; LUCZAK, Holger: Arbeitswissenschaft. Heidelberg u.a.: Springer, 3rd edition 2010.
- EBEL, Bernd: Produktionswirtschaft. Ludwigshafen am Rhein: Kiehl Friedrich Verlag, 9th edition 2009.

Please refer to the latest edition.

**Course: Occupational Safety and Environmental Protection (in German) [2110037]****Coordinators:** R. von Kiparski**Part of the modules:** SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 16: Industrial Engineering (p. 429)[SP\_16\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations****Elective Subject:** oral exam (ca. 30 min)**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

**Conditions**

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

**Recommendations**

- Knowledge of Human Factors Engineering is usefull

**Learning Outcomes**

The participant can

- explain the importance of occupational safety and environmental protection as well as their connection to each other.
- describe the influence of human behaviour.
- explain the possibilities and limits for an engineer to influence.
- realise if professional help of an expert of other faculties is needed.
- evaluate and present the results of his work.

**Content**

The participants have to solve a specific case study within the field of occupational safety and environmental protection. Therefore, the work in a team. The tasks covers the information research as well as the presentation of the results.

Content:

- Occupational Safety and Safety Engineering
- Environmental Protection within a Production Enterprise
- Health Management

Structure:

- Terminology
- Basics of Occupational Safety and Environmental Protection
- Case Study

- Moderated Processing of a Case Study within a Small Group

**Literature****Learning material:**

Handout and literature online ILIAS.

**Literature:**

- HACKSTEIN, R.: Arbeitswissenschaft im Umriß, Bd.1 und 2, Essen, 1977.
- HÜBLER, K.-H.; OTTO-ZIMMERMANN, K.: Bewertung der Umweltverträglichkeit. Taunusstein, 1989.
- KERN, P.; SCHMAUDE, M.: Einführung in den Arbeitsschutz für Studium und Berufspraxis. München: Hanser, 2005.
- KIPARSKI, R. v.: Rechtliche Grundlagen der Arbeitssicherheit Praxishandbuch für den Betriebsleiter. WEKA Verlag: Augsburg, 1997.
- GROB, R.: Erweiterte Wirtschaftlichkeits- und Nutzenrechnung. Köln, 1984.
- o.V.: Gefahrstoffverordnung 2005.
- o.V.: Geräte- und Produktsicherheitsgesetz 2004.
- o.V.: Arbeitssicherheitsgesetz 1973.
- o.V.: Arbeitsschutzgesetz 1996.
- o.V.: Berufsgenossenschaftliche Vorschriften und Regeln für Sicherheit- und Gesundheit bei der Arbeit.
- o.V.: Wörterbuch 'Arbeitssicherheit und Gesundheitsschutz' Wiesbaden, 2007.

Please refer to the latest edition.

**Course: Information Engineering [2122014]****Coordinators:** J. Ovtcharova, J. Ovtcharova**Part of the modules:** SP 28: Lifecycle Engineering (p. [443](#))[SP\_28\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term |                      |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content**

**Course: Information Systems in Logistics and Supply Chain Management [2118094]****Coordinators:** C. Kilger**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 19: Information Technology of Logistic Systems (p. 431)[SP\_19\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", version of 29.06.2011)

examination aids: none

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Students are able to:

- Describe requirements of logistical processes regarding IT systems,
- Choose information systems to support logistical processes and use them according to the requirements of a supply chain.

**Content**

- 1) Overview of logistics systems and processes
- 2) Basic concepts of information systems and information technology
- 3) Introduction to IS in logistics: Overview and applications
- 4) Detailed discussion of selected SAP modules for logistics support

**Media**

presentations

**Literature**

Stadtler, Kilger: Supply Chain Management and Advanced Planning, Springer, 4. Auflage 2008

**Remarks**

none

## Course: Information Processing in Mechatronic Systems [2105022]

**Coordinators:** M. Kaufmann

**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral, also possible as an optional or part of a major subject

### Conditions

None.

### Recommendations

Basic knowledge of computer science and programming

### Learning Outcomes

Students have fundamental knowledge about selection, conceptual design and development of information processing components in mechatronic systems.

### Content

Information processing components – consisting of sensors, actors, hardware and software – are of essential importance for the implementation of mechatronic functions.

Based on requirements on information processing in mechatronic systems typical hardware and software solutions are examined. Characteristics, advantages, disadvantages and application areas are discussed. Solutions are examined regarding real-time capabilities, dependability, safety and fault tolerance. Bus communication in mechatronic systems is examined. Description methods and several approaches of functional description are considered. An approach on the development of information processing components is developed. Lecture topics are complemented by practical examples.

Outline:

- Requirements on information processing components,
- Characteristics of information processing components
- Real-time capabilities, dependability, safety and fault tolerance
- Architectures of information processing components
- Communication in mechatronic systems
- Descriptive models und functional description
- Development of information processing components

Software quality

### Literature

- Marwedel, P.: Eingebettete Systeme. Springer: 2007.
- Teich, J.: Digitale Hard-, Software-Systeme. Springer: 2007.
- Wörn, H., Brinkschulte, U.: Echtzeitsysteme: Grundlagen, Funktionsweisen, Anwendungen. Springer, 2005.
- Zöbel, D.: Echtzeitsysteme: Grundlagen der Planung. Springer, 2008.

## Course: Information Processing in Sensor Networks [24102]

**Coordinators:** U. Hanebeck, F. Beutler

**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

### Learning Control / Examinations

The assessment is explained in the module description.

### Conditions

None.

### Recommendations

Knowledge of the lectures *Localization of Mobile Agents* [IN4INLMA] or *Stochastic Information Processing* [IN4INSIV] will be beneficial.

### Learning Outcomes

The student understands the specific challenges of information processing in the area of sensor networks and become acquainted with the different levels of processing procedures for the sensor measurements. The student is able to analyze, compare, and evaluate different approaches towards information processing in sensor networks.

### Content

In the lecture, relevant aspects of information processing in sensor networks are considered. First, the technical configuration of a single sensor node is presented. This includes the main components required for information processing, like sensor technology, analog signal processing, analog-to-digital conversion, and digital signal processing. In the second part, approaches for localization, time synchronization, routing, and sensor scheduling are presented. At the end of the lecture, approaches for sensor information fusion as well as the model-based reconstruction of distributed phenomena are discussed.

### Media

- Handwritten lecture notes will be made available electronically.
- Figures and application examples on slides.

More information can be retrieved from the information brochure available on the ISAS website.

### Literature

#### Elective literature:

Lecture notes.

**Course: Innovation Workshop: Mobility concepts for the year 2050 [2115916]****Coordinators:** P. Gratzfeld**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Written report and oral exam

**Conditions**

Attendance is mandatory during the whole seminar.

**Recommendations**

none

**Learning Outcomes**

- The students get aware of the mega and industry trends and learn about the innovation process of an international company in rail industry.
- They exercise advanced creativity techniques.
- They learn and deepen key qualifications like communication skills, presentation skills, moderation techniques and team work.
- They learn the appliance of a business plan as well as the usage of project management by practical examples.

**Content**

- Presentation of the company and the industry.
- Long term development of society and environment (megatrends), impact on railways and rail industry.
- Creating, elaborating and discussing innovative ideas by using the innovation tool "Zukunftswerkstatt".
- Different methods (Card Technique, Flash Light, Mind Map, Feedback, Elevator pitch, Business Plan, Project Management)
- Training and coaching of the individual presentation skills with final presentations in front of company representatives.

**Media**

All material is available for download (Ilias-platform).

**Literature**

Literature will be provided in advance and during the course.

**Remarks**

- This seminar is a 5-day block course.
- Number of participants is limited.
- Registration is necessary.
- For further information please look at the website [www.bahnsystemtechnik.de](http://www.bahnsystemtechnik.de).

**Course: Innovative Nuclear Systems [2130973]****Coordinators:** X. Cheng**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

- oral examination
- duration 20min

**Conditions**

None.

**Learning Outcomes**

This lecture is addressed to students of mechanical engineering, chemical engineering and physics. Goal of the lecture is the explanation of state-of-the-art development of nuclear systems. Nuclear systems, that are from todays point of view promising will be presented and explained. The main characteristics of such systems and the associated challenges are also part of the lecture.

**Content**

1. state of the art and development tendencies in nuclear systems
2. advanced concepts in light water cooled systems
3. new developments in fast reactors
4. development tendencies in gas-cooled plants
5. transmutation systems for waste management
6. fusionsystems

## Course: Integrative Strategies in Production and Development of High Performance Cars [2150601]

**Coordinators:** K. Schlichtenmayer

**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

The assessment is carried out as a written exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None

### Learning Outcomes

The students . . .

- are capable to specify the current technological and social challenges in automotive industry.
- are qualified to identify interlinkages between development processes and production systems.
- are able to explain challenges and solutions of global markets and global production of premium products.
- are able to explain modern methods to identify key competences of producing companies.

### Content

The lecture deals with the technical and organizational aspects of integrated development and production of sports cars on the example of Porsche AG. The lecture begins with an introduction and discussion of social trends. The deepening of standardized development processes in the automotive practice and current development strategies follow. The management of complex development projects is a first focus of the lecture. The complex interlinkage between development, production and purchasing are a second focus. Methods of analysis of technological core competencies complement the lecture. The course is strongly oriented towards the practice and is provided with many current examples.

The main topics are:

- Introduction to social trends towards high performance cars
- Automotive Production Processes
- Integrative R&D strategies and holistic capacity management
- Management of complex projects
- Interlinkage between R&D, production and purchasing
- The modern role of manufacturing from a R&D perspective
- Global R&D and production
- Methods to identify core competencies

### Media

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

### Literature

Lecture Slides

**Course: Integrated measurement systems for fluid mechanics applications [2171486]****Coordinators:** H. Bauer, Mitarbeiter**Part of the modules:** SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 5              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Group colloquia for each topic

Duration: approximately 10 minutes

no tools or reference materials may be used

**Conditions**

none

**Learning Outcomes**

The students are able to:

- theoretically describe and explain the fundamentals of computer aided measurements and adopt them practically
- apply the basics learned during the lecture to a practical problem in the form of a PC exercise

**Content**

The laboratory course offers an introduction into the acquisition of basic test data in fluid mechanics applications as well as a basic hands-on training for the application of modern PC based data acquisition methods. The combination of lectures about measurement techniques, sensors, signal converters, I/O systems, bus systems, data acquisition, handling and control routines and tutorials for typical fluid mechanics applications allows the participant to get a comprehensive insight and a sound knowledge in this field. The graphical programming environment LabVIEW from National Instruments is used in this course as it is one of the standard software tools for data acquisition worldwide.

Basic design of measurements systems

- Logging devices and sensors
- Analog to digital conversion
- Program design and programming methods using LabView
- Data handling
- Bus systems
- Design of a computer aided data acquisition system for pressure, temperature and derived parameters
- frequency analysis

**Literature**

Germer, H.; Wefers, N.: Meßelektronik, Bd. 1, 1985

LabView User Manual

Hoffmann, Jörg: Taschenbuch der Messtechnik, 6., aktualisierte. Aufl. , 2011

**Remarks**

Registration during the lecture period via the website.

**Course: Integrated Product Development [2145156]****Coordinators:** A. Albers**Part of the modules:** SP 20: Integrated Product Development (p. 432)[SP\_20\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 16           | 8              | Winter term | de                   |

**Learning Control / Examinations**

oral examination (60 minutes)

combined examination of lectures, tutorials and project work

**Conditions**

The participation in "Integrated Product Development" requires the concurrent participation in lectures (2145156), tutorials (2145157) and project work (2145300).

Due to organizational reasons, the number of participants is limited. Thus a selection has to be made. For registration to the selection process a standard form has to be used, that can be downloaded from IPEK homepage from april to july. The selection itself is made by Prof. Albers in personal interviews.

**Recommendations**

none

**Learning Outcomes**

The Students are able to ...

- analyze and evaluate product development processes based on examples and their own experiences.
- plan, control and evaluate the working process systematically.
- choose and use suitable methods of product development, system analysis and innovation management under consideration of the particular situation.
- prove their results.
- develop complex technical solutions in a team and to present them to qualified persons as well as non-qualified persons
- to design overall product development processes under consideration of market-, customer- and company-aspects

**Content**

organizational integration: integrated product engineering model, core team management and simultaneous engineering

informational integration: innovation management, cost management, quality management and knowledge management

personal integration: team coaching and leadership management

invited lectures

**Literature**

Klaus Ehrlenspiel - Integrierte Produktentwicklung. Denkabläufe, Methodeneinsatz, Zusammenarbeit, Hanser Verlag, 2009

**Remarks**

The lecture starts in first week of October.

**Course: Integrated production planning [2150660]****Coordinators:** G. Lanza**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 37: Production Management (p. 455)[SP\_37\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 6              | Summer term | de                   |

**Learning Control / Examinations**

The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

**Conditions**

None

**Recommendations**

Attendance of the lecture 'Manufacturing Engineering' [21657] prior to attending this lecture is recommended.

**Learning Outcomes**

The students . . .

- can discuss basic questions of production technology.
- are able to apply the methods of integrated production planning they have learned about to new problems.
- are able to analyze and evaluate the suitability of the methods, procedures and techniques they have learned about for a specific problem.
- can apply the learned methods of integrated production planning to new problems.
- can use their knowledge targeted for efficient production technology.

**Content**

As part of this lecture further engineering aspects of production technology are taught. This includes content from the manufacturing technology, machine tools and handling techniques as well as the organization and planning. Planning factories within the context of value networks and integrated production systems (Toyota etc.) requires an integrated perspective for the consideration of all functions included in the "factory" system. This includes the planning of manufacturing systems including the product, the value network and factory production, and the examination of SOPs, the running of a factory and maintenance. Content and theory covered by this lecture are completed with many examples from industry and exercises based on real-life situations and conditions.

Main topics covered by the lecture:

- The basic principles of production planning
- Links between product planning and production planning
- Integrating a production site into a production network
- Steps and methods of factory planning
- Approach to the integrated planning of manufacturing and assembly plants
- Layout of production sites
- Maintenance
- Material flow
- Digital factory
- Process simulation for material flow optimisation
- Start-up

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

## Course: Introduction to Neutron Cross Section Theory and Nuclear Data Generation [2190490]

**Coordinators:** R. Dagan

**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

### Learning Control / Examinations

oral exam, 30 min.

### Conditions

none

### Recommendations

none

### Learning Outcomes

The students:

- Understand the special importance of cross sections in various domains of natural science (Reactor physics, Material research, Solar radiation etc.)
- Are familiar with the theoretical methods and experimental effort to generate cross sections data.

### Content

Cross section characterization

Summary of basic cross section theory

Resonance cross section

Doppler broadening

Scattering kernels

Basic of slowing down theory

Unit cell based XS data generation

Cross sections Data libraries

Data Measurements

### Literature

Handbook of Nuclear Reactors Calculations Vol. I Y. Ronen, CRC Press 1986

D. Emendorfer, K.H. Höcker Theory of nuclear reactions, Parts I, II BI- Hochschultaschenbücher 1969 ( in German)

P. Tipler, R. Llewellyn Modern Physics 2008

**Course: IT-Fundamentals of Logistics [2118183]****Coordinators:** F. Thomas**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 19: Information Technology of Logistic Systems (p. 431)[SP\_19\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", latest version)

examination aids: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Students are able to:

- Describe and classify automation technology for material flow and the information technology necessary,
- identify, analyze and design the business processes in internal logistics,
- identify risks of failure and counteract and
- transfer the knowledge to practical implementations.

**Content**

This lecture, with exercises, treats automation technology in material flow as well as the information technology that has a direct relationship with it. In the first few chapters and exercises, an overview is given of the motors and conveying technology elements used in materials handling, and the sensors required for the purpose are explained. The target control types as well as the topic of coding techniques and RFID (GS1, barcodes, scanner, etc.) are treated in detail. Material flow controls are defined based on these chapters. Among other things, the functions of a stored-memory controller are explained in this section. Hierarchically classified control structures and their integration in network structures are considered in detail. The principles of communications systems (bus systems etc.) are supplemented with information on the use of the Internet as well as data warehousing strategies. An overview of modern logistics systems, especially in stores administration, illustrates new problem solution strategies in the area of information technology for logistics systems. After an analysis of the causes for system failures, measures are worked out for reducing the risks of failure. Furthermore, the objectives, task areas as well as various scheduling strategies in the area of transport management and control are presented. Worthwhile information on Europe-wide logistics concepts round off this practice-oriented lecture series. The presentation of the lectures will be multimedia-based. Exercises repeat and extend the knowledge principles imparted in the lectures and illustrate the subject with practical examples.

Focuses:

- System architecture for logistics solutions / Modularization of conveyors
- Material Flow Control System (MFCS) / Transport Handling
- Coding technique, GS 1 / RFID
- Data communication between controllers, computers and networks
- Business processes for internal logistics – software follows function

- Adaptive IT - Future-oriented software architecture
- System stability and data backup –Software-Engineering
- XTS – The Extensible Transport System

**Literature**

Detailed script can be downloaded online ([www.tup.com](http://www.tup.com)), updated and enhanced annually.

CD-ROM with chapters and exercises at the end of the semester available from the lecturer, also updated and enhanced annually.

**Remarks**

none

**Course: Introduction to Ceramics [2125757]****Coordinators:** M. Hoffmann**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 43: Technical Ceramics and Powder Materials (p. 462)[SP\_43\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (30 min) taking place at the agreed date.

The re-examination is offered upon agreement.

**Conditions**

none

**Recommendations**

Fundamentals in natural science are recommended for students in mechanical and industrial engineering. The lecture requires the basics of the material science courses in mechanical or industrial engineering for bachelor students.

**Learning Outcomes**

The students know the most relevant crystal structures and defects of non metallic inorganic materials, are able to read binary and ternary phase diagrams and are familiar with powder technological shaping techniques, sintering and grain growth. They know the basics of the linear elastic fracture mechanics, are familiar with Weibull statistics, K-concept, subcritical crack growth, creep and the opportunities for microstructural reinforcement of ceramics. The students are able to explain the correlation among chemical bonding, crystal and defect structures and the electrical properties of ceramics.

**Content**

After a short introduction to interatomic bonding, fundamental concepts of crystallography, the stereographic projection and the most important symmetry elements will be given. Different types of crystal structures are explained and the relevance of imperfections are analysed with respect to the mechanical and electrical properties of ceramics. Then, the impact of surfaces, interfaces and grain boundaries for the preparation, microstructural evolution and the resulting properties is discussed. Finally, an introduction is given to ternary phase diagrams.

The second part of the course covers structure, preparation and application aspects of nonmetallic inorganic glasses, followed by an introduction to the properties and processing methods of fine-grained technical powders. The most relevant shaping methods, such as pressing, slip casting, injection moulding and extrusion are introduced. Subsequently, the basics of science of sintering and the mechanisms for normal and abnormal grain growth are discussed. Mechanical properties of ceramics are analysed using basic principles of linear elastic fracture mechanics, Weibull statistics, concepts for subcritical crack growth and creep models to explain the behaviour at elevated temperatures. Furthermore it is demonstrated that mechanical properties can be significantly enhanced by various types of microstructural toughening mechanisms. The electronic and ionic conductivity of ceramic materials are explained based on defect-chemical considerations and band structure models. Finally, the characteristics of a dielectric, pyroelectric, and piezoelectric behaviour is discussed.

**Media**

Slides for the lecture:

available under <http://www.iam.kit.edu/km>

**Literature**

- H. Salmang, H. Scholze, "Keramik", Springer
- Kingery, Bowen, Uhlmann, "Introduction To Ceramics", Wiley
- Y.-M. Chiang, D. Birnie III and W.D. Kingery, "Physical Ceramics", Wiley
- S.J.L. Kang, "Sintering, Densification, Grain Growth & Microstructure", Elsevier

**Course: Ceramics Processing [2126730]****Coordinators:** J. Binder**Part of the modules:** SP 43: Technical Ceramics and Powder Materials (p. 462)[SP\_43\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (approx. 20 min) taking place at the agreed date.

Auxiliary means: none

The re-examination is offered upon agreement.

**Conditions**

none

**Recommendations**

Basics of the course "Introduction to Ceramics" should be known.

**Learning Outcomes**

The students are able to name the major ceramic process technologies and explain their specifics in detail. Additionally, they are capable of illustrating the correlations between the individual processes and their importance for the production of engineering ceramics. The students are able to relate processing effects to material properties. Furthermore the students can apply the basics to concrete tasks. They are able to comprehend and assess information in professional articles.

**Content**

The course imparts technological basics for processing of engineering ceramics. The course is arranged in the following units:

- Synthesis methods
- Powder conditioning and mixing methods
- Forming of ceramics
- Sintering
- Finishing processes
- Ceramic films and multi-layer systems
- Effects of processing on properties

**Literature**

W. Kollenberg: Technische Keramik, Vulkan Verlag 2010.

M. N. Rahaman: Ceramic Processing, CRC Taylor & Francis, 2007.

D.W. Richerson: Modern ceramic engineering, CRC Taylor & Francis, 2006.

A. G. King: Ceramic Technology and Processing, William Andrew, 2002.

**Course: Nuclear Power Plant Technology [2170460]****Coordinators:** T. Schulenberg, K. Litfin**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

The students know the design and operation of major components of nuclear power plants with pressurized water reactors and boiling water reactors.

**Content**

Power plants with pressurized water reactors:

Design of the pressurized water reactor

- Fuel assemblies
- Control rods and drives
- Core instrumentation
- Reactor pressure vessel and its internals

Components of the primary system

- Primary coolant pumps
- Pressurizer
- Steam generator
- Water make-up system

Secondary system:

- Turbines
- Reheater
- Feedwater system
- Cooling systems

Containment

- Containment design
- Components of safety systems
- Components of residual heat removal systems

Control of a nuclear power plant with PWR

Power plants with boiling water reactors:

Design of the boiling water reactor

- Fuel assemblies
- Control elements and drives
- Reactor pressure vessel and its internals

Containment and components of safety systems  
Control of a nuclear power plant with boiling water reactors

**Media**

Powerpoint presentations

**Literature**

lecture notes

**Remarks**

The lecture "Nuclear Power Plant Technology" given in the winter semester has been cancelled instead

**Course: Cognitive Automobiles - Laboratory [2138341]****Coordinators:** C. Stiller, M. Lauer, B. Kitt**Part of the modules:** SP 40: Robotics (p. 458)[SP\_40\_mach], SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Colloquia, final race

**Conditions**

Lectures “Automotive Vision” and “Behaviour Generation for Vehicles” have to be attended in parallel. Basic knowledge of a programming language is a plus.

**Learning Outcomes**

The laboratory accompanies the lectures “Automotive Vision” and “Behaviour Generation for Vehicles”. It will provide the opportunity of turning theoretical skills taught in the lecture to practice. The laboratory is divided into four groups with a maximum number of five students in each group. During the lessons you will be supervised by scientific staff.

The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Machine vision, vehicle kinematics and advanced information processing techniques are presented to provide a broad overview on “seeing vehicles”. Each group is given the task to extract lane markings from video images and generate a suitable trajectory which the vehicle should follow. Apart from technical aspects in a highly innovative field of automotive technology, participants have the opportunity of gathering important qualifications as i.e. implementation skills, acquisition and comprehension of suitable literature, project and team work.

**Content**

1. Lane recognition
2. Object detection
3. Vehicle lateral control
4. Vehicle longitudinal control
5. Collision avoidance

**Literature**

TBA

**Course: Cognitive Systems [24572]****Coordinators:** R. Dillmann, A. Waibel**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Summer term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Recommendations**

Basic knowledge in informatics is helpful.

**Learning Outcomes**

- The relevant elements of technical cognitive systems can be named and their tasks can be described.
- The problems in the relevant areas can be recognized and processed.
- Further approaches and methods can be exploited autonomously and applied successfully.
- Variations of the problems can be solved successfully.
- The educational objectives shall be achieved by visiting the complementary tutorials.

**Content**

Cognitive systems act on the basis of perception and knowledge. After reception of stimuli through receptors, the signals are processed, and based on a knowledge base actions are triggered. In the lecture, the involved modules of a cognitive system are presented. To these belong in addition to acquisition and processing of environmental information (e.g. images, speech), the representation of knowledge as well as the assignment of features with the aid of classifiers. Further core themes of the lecture will be learning and planning methods, and their implementation. The presented methods and approaches will be deepened in the tutorials by means of exercises.

**Media**

Slides, lecture notes (available for download)

**Literature**

„Artificial Intelligence – A Modern Approach“, Russel, S.; Norvig, P.; Prentice Hall. ISBN 3895761656.

**Elective literature:**

„Computer Vision – Das Praxisbuch“, Azad, P.; Gockel, T.; Dillmann, R.; Elektor-Verlag. ISBN 0131038052.

“Discrete-Time Signal Processing”, Oppenheim, Alan V.; Schafer, Roland W.; Buck, John R.; Pearson US Imports &amp; PHIPES. ISBN 0130834432.

“Signale und Systeme”, Kiencke, Uwe; Jäkel, Holger; Oldenbourg, ISBN 3486578111.

**Course: Coal fired power plants [2169461]****Coordinators:** P. Fritz, T. Schulenberg**Part of the modules:** SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

Knowledge in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.

**Recommendations**

None.

**Learning Outcomes**

After completion, the students know the layout of different coal fired power plants, the design of their major components, as well as the operational conditions and their limits.

**Content**

The lecture presents the technology of coal fired power plants, which are conventional steam turbine plants as well as advanced combined cycle power plants with integrated coal gasification. It includes combustion systems, steam generators, a short overview over steam turbine technologies, the cooling system and the water supply system as well as the off gas treatment. Coal gasification will be explained with fixed bed, fluidized bed and entrained flow gasifiers. The integrated coal gasification combined cycle includes also the raw gas purification system. In addition, a visit to a coal fired power plant will be offered.

**Media**

power point presentation

**Literature**

Everett B. Woodruff, Herbert B. Lammers, Thomas F. Lammers, Steam Plant Operation, 9th Edition, McGraw Hill, New York 2012

**Course: Design with Plastics [2174571]****Coordinators:** M. Liedel**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 36: Polymer Engineering (p. 454)[SP\_36\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach], SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral duration: 20 - 30 min. aids: none

**Conditions**

none, recomm. 'Polymer Engineering I'

**Learning Outcomes**

Students will be able to

- distinguish polymer compounds from other construction materials regarding chemical differences, thermal behaviour and solid conditions.
- discuss main plastics processes regarding advantages and disadvantages of materials selection and part geometry design and to make appropriate selections.
- analyze complex application requirements concerning material impacts on strength and to use the classic dimensioning method specific to the application to evaluate the lifetime part strength limit.
- evaluate part tolerances and geometry by appropriate methods considering molding shrinkage, production tolerances, post shrinkage, heat expansion, swelling, elastic and creep deformation.
- design plastic specific joining geometries like snap fits, screw bosses, weld seams and film hinges.
- detect classic molding failures and understand potential causes as well as to reduce the probability of molding failures by defining an optimized design.
- understand benefits and limits of selected simulation tools in the plastic technology discipline (strength, deformation, filling, warpage).
- assess polymer classes and plastic part designs with respect to suitable recycling concepts and ecological consequences.

**Content**

Structure and properties of plastics materials,  
 Processing of plastics,  
 Behavior of plastics under environmental impacts,  
 Classic strength dimensioning,  
 Geometric dimensioning,  
 Plastic appropriate design,  
 Failure examples,  
 Joining of plastic parts,  
 Supporting simulation tools,  
 Structural foams,  
 Plastics Technology trends.

**Literature**

Scriptum will be handed out during the lecture.  
 Recommended literature are provided in the lecture.

## Course: Lightweight Engineering Design [2146190]

**Coordinators:** A. Albers, N. Burkardt

**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

The type of examination (written or oral) will be announced at the beginning of the lecture.

written examination: 60 min duration

oral examination: 20 min duration

Auxiliary means: none.

### Conditions

none

### Learning Outcomes

The students are able to ...

- name the central strategies of lightweight construction and their connections and to illustrate them on examples.
- list different stiffening methods in relation to computer-based design.
- evaluate the capacity of computer-based design as well as the related limits and influences on the manufacturing.
- reflect the basics of lightweight construction in the overall framework related to the product engineering process.

### Content

General aspects of lightweight design, lightweight strategies, construction methods, design principles, lightweight construction, stiffening techniques, lightweight materials, virtual product engineering, bionics, joining techniques, validation, recycling

Additionally, guest speakers from industry will present lightweight design from an practical point of view.

### Media

Beamer

### Literature

Klein, B.: Leichtbau-Konstruktion. Vieweg & Sohn Verlag, 2007

Wiedemann, J.: Leichtbau: Elemente und Konstruktion, Springer Verlag, 2006

Harzheim, L.: Strukturoptimierung. Grundlagen und Anwendungen. Verlag Harri Deutsch, 2008

### Remarks

Lecture slides are available via eLearning-Platform ILIAS.

**Course: Vibration of continuous systems [2161214]****Coordinators:** H. Hetzler**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral exam., 30min

**Conditions**

None.

**Learning Outcomes****Content**

This lecture is on vibrations of continuous systems. After an introduction into the topic and a definition of basic concepts and calculation approaches, 1-parametric continua (strings, bars) and 2-parametric continua (membranes, plates) are discussed into detailed. Based on these basic models, a brief outlook to more complex geometries is given. Beyond these basis issues more advanced topics (like elastic rotors) are discussed as well.

**Literature**

Literature recommendations are given in the lecture.

**Course: Power and Heat economics [2169452]****Coordinators:** H. Bauer**Part of the modules:** SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students are able to comment on and judge the economical and political aspects of the power and heat market from an economical point of view. They have the capability to explain the basic economical criteria and to describe the relevance of the power and heat market in practice. The students can apply their gained economical knowledge to practical examples from the international power business and can comment on the interaction of politics and business.

**Content**

Introduction

Overview of the power market in Germany and Europe

Costs of electricity generation

Costs of heat generation

Financing: Analysis of profit, liquidity, balance and return on investment

Cost of power production of different power plants and sensitivities

District heating (Example: Aerea Rhein/Ruhr)

Structure of rates and pricing in the German power market

**Course: Motor Vehicle Laboratory [2115808]****Coordinators:** M. Frey, M. Bürckert**Part of the modules:** SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Colloquium before each experiment

After completion of the experiments: written examination

Duration: 90 minutes

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students have deepened their knowledge on motor vehicles acquired in lectures and can apply it practically. They have an overview of the applied measuring technique and can execute and analyse measurements for the handling of given problem definitions. They are ready to analyze and to judge measurement results.

**Content**

1. Determination of the driving resistances of a passenger vehicle on a roller dynamometer; measurement of the engine performance of the test vehicle
2. Investigation of a twin-tube and a single-tube shock absorber
3. Behavior of car tyres under longitudinal forces and lateral forces
4. Behavior of car tires on wet road surface
5. Rolling resistance, energy dissipation and high-speed strength of car tires
6. Investigation of the moment transient characteristic of a Visco clutch

**Literature**

1. Matschinsky, W: Radführungen der Straßenfahrzeuge, Verlag TÜV Rheinland, 1998
2. Reimpell, J.: Fahrwerktechnik: Fahrzeugmechanik, Vogel Verlag, 1992
3. Gnadler, R.: Documents to the Motor Vehicle Laboratory

**Course: Cooling of thermally high loaded gas turbine components [2170463]****Coordinators:** H. Bauer, A. Schulz**Part of the modules:** SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

The students are able to:

- name and differentiate between different cooling methods and analyse them
- judge on the advantages and disadvantages of cooling methods and discuss approaches for the improvement of complex cooling methods
- to outline the basics of forces convective heat transfer and film cooling
- design cooled gas turbine components in a simplified manner
- comment on the experimental and numerical methods for the characterisation of heat transfer

**Content**

Hot gas temperatures of modern gas turbine engines exceed the maximum tolerable material temperatures by several hundreds of K. To ensure reliability of lifetime, complex cooling technology must be applied. Various cooling methods will be introduced in this lesson. Specific pros and cons will be identified and new concepts for further improvement of cooling will be discussed. Furthermore, the fundamentals of forced convection heat transfer and film cooling will be imparted and a simplified design process of a cooled gas turbine components will be demonstrated. Finally, experimental and numerical methods for the characterization of heat transfer will be presented.

## Course: Warehousing and distribution systems [2118097]

**Coordinators:** M. Schwab, J. Weiblen

**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach], SP 19: Information Technology of Logistic Systems (p. 431)[SP\_19\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral / written (if necessary) => (see "Studienplan Maschinenbau", version 29.06.2011)

### Conditions

none

### Recommendations

logistics lecture

### Learning Outcomes

Students are able to:

- Describe the areas of typical warehouse and distribution systems with the respective processes and can illustrate it with sketches,
- Use and choose strategies of warehouse and distribution systems according to requirements,
- Classify typical systems using criteria discussed in the lecture, and
- Reason about the choice of appropriate technical solutions.

### Content

- Introduction
- Yard management
- Receiving
- Storage and picking
- Workshop on cycle times
- Consolidation and packing
- Shipping
- Added Value
- Overhead
- Case Study: DCRM
- Planning of warehouses
- Case study: Planning of warehouses
- Distribution networks
- Lean Warehousing

**Media**

presentations, black board

**Literature**

**ARNOLD, Dieter, FURMANS, Kai (2005)**

Materialfluss in Logistiksystemen, 5. Auflage, Berlin: Springer-Verlag

**ARNOLD, Dieter (Hrsg.) et al. (2008)**

Handbuch Logistik, 3. Auflage, Berlin: Springer-Verlag

**BARTHOLDI III, John J., HACKMAN, Steven T. (2008)**

Warehouse Science

**GUDEHUS, Timm (2005)**

Logistik, 3. Auflage, Berlin: Springer-Verlag

**FRAZELLE, Edward (2002)**

World-class warehousing and material handling, McGraw-Hill

**MARTIN, Heinrich (1999)**

Praxiswissen Materialflußplanung: Transport, Hanshaben, Lagern, Kommissionieren, Braunschweig, Wiesbaden: Vieweg

**WISSER, Jens (2009)**

Der Prozess Lagern und Kommissionieren im Rahmen des Distribution Center Reference Model (DCRM); Karlsruhe : Universitätsverlag

A comprehensive overview of scientific papers can be found at:

**ROODBERGEN, Kees Jan (2007)**

Warehouse Literature

**Remarks**

none

**Course: Laser in automotive engineering [2182642]****Coordinators:** J. Schneider**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination (30 min)

no tools or reference materials

**Conditions**

Basic knowledge of physics, chemistry and material science is assumed.

It is not possible, to combine this lecture with the lecture *Physical basics of laser technology* [2181612].**Recommendations**

None.

**Learning Outcomes**

The student

- can explain the principles of light generation, the conditions for light amplification as well as the basic structure and function of Nd:YAG-, CO<sub>2</sub>- and high power diode-laser sources.
- can describe the most important methods of laser-based processing in automotive engineering and illustrate the influence of laser, material and process parameters
- can analyse manufacturing problems and is able to choose a suitable laser source and process parameters.
- can explain the requirements for safe handling of laser radiation and for the design of safe laser systems.

**Content**

Based on a short description of the physical basics of laser technology the lecture reviews the most important high power lasers and their various applications in automotive engineering. Furthermore the application of laser light in metrology and safety aspects will be addressed.

- physical basics of laser technology
- laser beam sources (Nd:YAG-, CO<sub>2</sub>-, high power diode-laser)
- beam properties, guiding and shaping
- basics of materials processing with lasers
- laser applications in automotive engineering
- economical aspects
- safety aspects

**Media**

lecture notes via ILIAS

**Literature**

W. M. Steen: Laser Material Processing, 2010, Springer

W. T. Silfvast: Laser Fundamentals, 2008, Cambridge University Press

**Remarks**

It is allowed to select only one of the lectures "Laser in automotive engineering" (2182642) or "Physical basics of laser technology" (2181612) during the Bachelor and Master studies.

**Course: Leadership and Product Development [2145184]****Coordinators:** A. Ploch**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 20: Integrated Product Development (p. 432)[SP\_20\_mach], SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term |                      |

**Learning Control / Examinations**

oral exam

**Conditions**

none

**Learning Outcomes**

The students are able to name, explain und discuss the main elements of leadership theories, methods and management development basics as well as the bordering topics of change management, intercultural competences, team work and corporate governance.

**Content**

Leadership theories  
 Management tools  
 Communication as management tool  
 Change management  
 Management development and MD-Programs  
 Assessment center and management audits  
 Team work, team development und team roles  
 Intercultural competences  
 Leadership and ethics, Corporate Governance  
 Executive Coaching  
 Lectures of industrial experts

**Course: Laboratory Exercise in Energy Technology [2171487]****Coordinators:** H. Bauer, U. Maas, H. Wirbser**Part of the modules:** SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 4              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

1 report, approx. 12 pages

Discussion of the documented results with the assistants

Duration: 30 minutes

no tools or reference materials may be used

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Attending this course enables the students to:

- accomplish experimental and design related as well as theoretical tasks in a scientific background
- perform a correct evaluation of the obtained results
- adequately document and present their results in a scientific framework

**Content**

- Micro gas turbine
- Several test rigs for the investigation of heat transfer at thermally high loaded components
- Optimization of components of the internal air and oil system
- Characterization of spray nozzles
- Investigation of pollutant and noise emission as well as reliability and material deterioration
- Exhaust gas treatment
- Exhaust gas turbocharger
- Cooling Tower
- Heatpump
- Plant oil stove
- Heatcapacity
- Wood combustion

**Remarks**Online registration within the first two weeks of the lecture periode at: <http://www.its.kit.edu>

**Course: Logistics - organisation, design and control of logistic systems [2118078]****Coordinators:** K. Furmans**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 19: Information Technology of Logistic Systems (p. 431)[SP\_19\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Summer term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", version of 29.06.2011)

examination aids: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Students are able to:

- Describe logistical tasks,
- Design logistical systems suitable to the respective task,
- Dimension stocastical stock models,
- Determine essential influencing parameters on the bullwhip effect and
- Use optimizing solution methods.

**Content**

multistage logistic process chains

transport chain in logistic networks

distribution processes

distribution centers

logistics of production systems

dependencies between production and road traffic

information flow

cooperative strategies (like kanban, just-in-time, supply chain management)

**Media**

presentations, black board

**Literature**

None.

**Remarks**

none

**Course: Automotive Logistics [2118085]****Coordinators:** K. Furmans**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", version of 29.06.2011)

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Students are able to:

- Describe essential logistic questions, in a complex production network. As an example the automobile industry is used.
- Choose and apply solution possibilities for logistic problems in this area.

**Content**

- Logistic questions within the automobile industry
- basic model of automobile production and distribution
- relation with the suppliers
- Disposition and physical execution
- Vehicle production in the interaction of shell, paint shop and assembly
- Sequence planning
- Assembly supply
- vehicle distribution and linkage with selling processes
- Physical execution, planning and control

**Media**

presentations, black board

**Literature**

None.

**Remarks**

none

**Course: Airport logistics [2117056]****Coordinators:** A. Richter**Part of the modules:** SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 19: Information Technology of Logistic Systems (p. 431)[SP\_19\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", version of 29.06.2011)

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Students are able to:

- Describe material handling and informations technology activities on airports,
- Evaluate processes and systems on airports as the law stands, and
- Choose appropriate processes and material handling systems for airports.

**Content**

Introduction  
 airport installations  
 luggage transport  
 passenger transport  
 security on the airport  
 legal bases of the air traffic  
 freight on the airport

**Media**

presentations

**Literature**

None.

**Remarks**

none

## Course: Localization of Mobile Agents [24613]

**Coordinators:** U. Hanebeck, M. Baum

**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

### Learning Control / Examinations

#### Conditions

None.

#### Recommendations

Basic knowledge of probability theory and linear algebra will be beneficial.

### Learning Outcomes

- The student learns the understanding of the problem, solution methods, and the required mathematical background.
- A further objective is to delve into the theoretical foundations, the distinction of the basic localization methods including their advantages and disadvantages. For this purpose, a variety of applications are considered.

### Content

This module provides a systematic introduction into the topic of localization methods. In order to facilitate the access, the module is composed into four main topics. Dead reckoning treats the instantaneous determination of a vehicle's position based on dynamic parameters like velocity or steering angle. Localization with the help of measurements of known landmarks is part of the so-called static localization. Besides of closed-form solutions for particular measurements (distances and angles), the least squares method for fusion arbitrary measurements is introduced. Dynamic localization treats the combination of dead reckoning and static localization. The essential part is the derivation of the Kalman filter, which is successfully applied in many practical applications. In the end, simultaneous localization and mapping (SLAM) is introduced, which allows localization in case of (partly) unknown landmark positions.

### Media

- Handwritten lecture notes will be made available electronically.
- Figures and application examples on slides.
- More information can be retrieved from the information brochure available on the ISAS website.

### Literature

#### Elective literature:

Lecture notes.

**Course: Machine Vision [2137308]****Coordinators:** C. Stiller, M. Lauer**Part of the modules:** SP 40: Robotics (p. 458)[SP\_40\_mach], SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 18: Information Technology (p. 430)[SP\_18\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes

no reference materials

**Conditions**

Basic studies and preliminary examination; fundamentals in measurement, system and control theory, e.g. from the lecture "Measurement and Control Systems"

**Learning Outcomes**

Machine vision (or computer vision) describes the computer supported solution of visual tasks similar to a human. The technical domain machine vision incorporates numerous research areas like optics, digital image processing, 3D measurement technology and pattern recognition. One main focus is image understanding having the goal to gather the meaning of an image and draw conclusions from this semantic meaning. The subjects in the course machine vision are similar to the standard image processing procedure. The students shall acquire an overview on major Machine Vision methods and gather practical experience from computer exercises and experiments.

**Content**

1. Illumination
2. Image acquisition
3. Image preprocessing
4. Feature extraction
5. Stereo Vision
6. Robust parameter estimation
7. Classification and interpretation

**Literature**

Main results are summarized in pdf-file. Further recommendations will be presented in the lecture.

## Course: Magnet Technology of Fusion Reactors [2190496]

**Coordinators:** W. Fietz, K. Weiss

**Part of the modules:** SP 53: Fusion Technology (p. 471)[SP\_53\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

### Learning Control / Examinations

Oral examination of about 30 minutes

### Conditions

None.

### Recommendations

Knowledge in energy technology, power plants, material testing is welcomed

### Learning Outcomes

The students know:

- Basic knowledge of superconductivity, superconducting cables and magnet construction
- Generation of low temperature, cryostat construction
- Material properties at low temperatures
- Magnet design and magnet safety
- High-temperature superconductor use in power application and magnet construction

### Content

The goal of the lecture is to impart the fundamentals of construction of superconducting magnets. Magnet technology is inherently of multidisciplinary character e.g. material properties at low temperature, high voltage and high current technique. The use of superconductors is mandatory to reach highest magnetic fields with comparable small losses. Examples of magnets from power application, basic research and fusion reactor construction are discussed.

### Lecture Content:

- Introduction to plasma, fusion and electromagnets
- Introduction superconductivity - basics and materials
- Creation of low temperatures, cryo-technique
- Material properties at low temperature
- Magnet design and calculation
- Magnet stability, quench safety and high voltage protection
- Magnet examples
- High-temperature superconductors (HTS)
- HTS-application (cable, motor/generator, FCL, current leads, fusion reactors)

**Course: Magnetohydrodynamics [2153429]****Coordinators:** L. Bühler**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 53: Fusion Technology (p. 471)[SP\_53\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral,  
Duration: 30 minutes  
No auxiliary means

**Conditions**

none

**Learning Outcomes**

The students can describe the fundamentals of magnetohydrodynamics. They are qualified to explain the interrelations of electro and fluid dynamics so as to analyze magnetohydrodynamic flows in engineering applications or for phenomena in geo and astrophysics.

**Content**

- Introduction
- Basics of electro and fluid dynamics
- Exact solutions, Hartmann flow, pump, generator, channel flows
- Inductionless approximation
- Developing flows, change of cross-section, variable magnetic fields
- Alfvén waves
- Stability, transition to turbulence
- Liquid dynamos

**Literature**

U. Müller, L. Bühler, 2001, Magnetofluidynamics in Channels and Containers, ISBN 3-540-41253-0, Springer  
 R. Moreau, 1990, Magnetohydrodynamics, Kluwer Academic Publisher  
 P. A. Davidson, 2001, An Introduction to Magnetohydrodynamics, Cambridge University Press  
 J. A. Shercliff, 1965, A Textbook of Magnetohydrodynamics, Pergamon Press

## Course: Leadership and Conflict Management (in German) [2110017]

**Coordinators:** H. Hatzl

**Part of the modules:** SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 37: Production Management (p. 455)[SP\_37\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

**Optional Subject Economics/Law:** oral exam (ca. 30 min)

### Conditions

- Compact course
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

### Recommendations

- Knowledge of Work science and economics is usefull

### Learning Outcomes

- Knowledge about techniques for management and leadership
- Preparation for the management and leadership in the job

### Content

1. Introduction to the course
2. Goal definition and goal achievement
3. Management techniques within planning
4. Communication and information
5. Decision-making
6. Leadership and co-operation
7. Self management
8. Conflict management
9. Case studies

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- ALLHOFF, D.-W.; ALLHOFF, W.: Rhetorik und Kommunikation. Regensburg: Bayerischer Verlag für Sprechwissenschaft, 2000.

- ARMSTRONG, M.: Führungsgrundlagen. Wien, Frankfurt/M.: Ueberreuter, 2000.
- BUCHHOLZ, G.: Erprobte Management-Techniken. Renningen-Malmsheim : expert-Verlag, 1996.
- RICHARDS, M. D.; GREENLAW, P. S.: Management Decision Making. Homewood: Irwin, 1966.
- SCHNECK, O.: Management-Techniken, Frankfurt/M., New York: Campus Verlag, 1996.

Please refer to the latest edition.

**Course: Machine Dynamics [2161224]****Coordinators:** C. Proppe**Part of the modules:** SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], (p. 475)[SP\_58\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | en                   |

**Learning Control / Examinations**

Written examination (compulsory subject), auxiliary means: own manuscripts

Oral examination (optional subject) , no auxiliary means allowed

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Students are able to apply engineering-oriented calculation methods in order to model and to understand dynamic effects in rotating machinery. This includes the investigation of runup, stationary operation of rigid rotors including balancing, transient and stationary behavior of flexible rotors, critical speeds, dynamics of slider-crank mechanisms, torsional oscillations.

**Content**

1. Introduction
2. Machine as mechatronic system
3. Rigid rotors: equations of motion, transient and stationary motion, balancing
4. Flexible rotors: Laval rotor (equations of motion, transient and stationary behavior, critical speed, secondary effects), refined models)
5. Slider-crank mechanisms: kinematics, equations of motion, mass and power balancing

**Literature**

Biezeno, Grammel: Technische Dynamik, 2. Edition, 1953

Holzweißig, Dresig: Lehrbuch der Maschinendynamik, 1979

Dresig, Vulfson: Dynamik der Mechanismen, 1989

**Course: Machine Dynamics II [2162220]****Coordinators:** C. Proppe**Part of the modules:** SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], (p. 475)[SP\_58\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

**Learning Control / Examinations**

oral exam, no auxiliary means allowed

**Conditions**

none

**Recommendations**

Machine Dynamics

**Learning Outcomes**

Students are able to develop and analyze detailed models in machine dynamics that encompass continuum models, fluid structure interaction, and stability analyses.

**Content**

- hydrodynamic bearings
- rotating shafts in hydrodynamic bearings
- belt drives
- vibration of turbine blades

**Literature**

R. Gasch, R. Nordmann, H. Pfützner: Rotordynamik, Springer, 2006

**Course: Material flow in logistic systems [2117051]****Coordinators:** K. Furmans**Part of the modules:** SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", current version)

**Conditions**

none

**Recommendations**Recommended compulsory optional subject:  
Stochastics in mechanical engineering**Learning Outcomes**

Students are able to:

- describe material flow processes qualitativ and quantitativ,
- assign possibilities of technical solutions to a open operational task,
- plan material flow systems, illustrate them in simple models and analyse them regarding their performance,
- use methods to determine performance indicators like throughput, utilization, etc., and
- evaluate material flow systems regarding performance and availability.

**Content**

- elements of material flow systems (conveyor elements, fork, join elements)
- models of material flow networks using graph theory and matrices
- queueing theory, calculation of waiting time, utilization
- warehouseing and order-picking
- shuttle systems
- sorting systems
- simulation
- calculation of availability and reliability
- value stream analysis

**Media**

presentations, black board, book

**Literature****Arnold, Dieter; Furmans, Kai** : Materialfluss in Logistiksystemen; Springer-Verlag Berlin Heidelberg, 2009**Remarks**

none

## Course: Materials and Processes for Body Lightweight Construction in the Automotive Industry [2149669]

**Coordinators:** D. Steegmüller, S. Kienzle

**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None

### Recommendations

None

### Learning Outcomes

The students . . .

- are able to name the various lightweight approaches and identify possible areas of application.
- are able to identify the different production processes for manufacturing lightweight structures and explain their functions.
- are able to perform a process selection based on the methods and their characteristics.
- are able to evaluate the different methods against lightweight applications on the basis of technical and economic aspects.

### Content

The objective of the lecture is to build up an overview of the relevant materials and processes for the production of a lightweight body. This includes both the actual production and the joining for the body. The lecture covers the different lightweight approaches and possible fields of application in the automotive industry. The methods are discussed with practical examples from the automotive industry.

The following topics will be covered:

- lightweight designs
- aluminum and steel for lightweight construction
- fibre-reinforced plastics by the RTM and SMC process
- joining of steel and aluminum (clinching, riveting, welding)
- bonding
- coating
- finishing
- quality assurance
- virtual factory

### Media

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

### Literature

Lecture Notes

### Remarks

None

**Course: Mathematical Foundation for Computational Mechanics [2162240]****Coordinators:** E. Schnack**Part of the modules:** SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination. Duration: 30 minutes.

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The aim is the efficient and targeted application of mathematical methods for modern numerics in mechanical engineering. Students will gain fundamental knowledge of mathematical methods for variational calculus for elastic, dynamic and multi-field continuum calculations. They will gain knowledge of functional analysis which will enable them to understand error estimations in the finite element method (FEM) and the boundary element method (BEM).

**Content**

Variational formulations. Functional analysis. Lagrange d process. Various function space definitions relating to the elasticity and dynamics of the mechanics. Measurements which enable the field calculation to be defined in applications.

**Literature**

Script (available in administration office, building 10.91, rm. 310).

**Course: Mathematical Methods in Dynamics [2161206]****Coordinators:** C. Proppe**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 2              | Winter term | de                   |

**Learning Control / Examinations**

written examination (compulsory subject), auxiliary means: own manuscripts allowed  
 oral examination (optional subject) no auxiliary means allowed

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The students know the mathematical methods of dynamics precisely. They are able to use the basic mathematical methods for modelling the dynamical behaviour of elastic and rigid bodies.

The students have a basic understanding of the description of kinematics and kinetics of bodies. They also master the alternative formulations based on weak formulations and variational methods and the approximate solution methods for numerical calculations of the moving behaviour of elastic bodies.

**Content**

Dynamics of continua:

Concept of continuum, geometry of continua, kinematics and kinetics of continua

Dynamics of rigid bodies:

Kinematics and kinetics of rigid bodies

Variational principles:

Principle of virtual work, variational calculations, Principle of Hamilton

Approximate solution methods:

Methods of weighted residuals, method of Ritz

Applications

**Literature**

Lecture notes (available online)

J.E. Marsden, T.J.R. Hughes: Mathematical foundations of elasticity, New York, Dover, 1994

P. Haupt: Continuum mechanics and theory of materials, Berlin, Heidelberg, 2000

M. Riemer: Technische Kontinuumsmechanik, Mannheim, 1993

K. Willner: Kontinuums- und Kontaktmechanik : synthetische und analytische Darstellung, Berlin, Heidelberg, 2003

J.N. Reddy: Energy Principles and Variational Methods in applied mechanics, New York, 2002

A. Boresi, K.P. Chong, S. Saigal: Approximate solution methods in engineering mechanics, New York, 2003

**Course: Mathematical Methods in Strength of Materials [2161254]****Coordinators:** T. Böhlke**Part of the modules:** SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Winter term | de                   |

**Learning Control / Examinations**

depending on choice according to actual version of study regulations

Additives as announced

Prerequisites are met by solution of homework problems

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students can

- perform the most important tensor operations in example problems
- classify tensors of second order according to their properties
- apply elements of tensoranalysis
- describe the kinematics of infinitesimal and finite deformations in tensorial notation
- derive balance laws of mechanics
- solve problems of elasticity and thermoelasticity using tensor notation
- apply the theoretical concepts of the lecture to special problems

**Content**

Tensor algebra

- vectors; basis transformation; dyadic product; tensors of 2nd order
- properties of 2nd order tensors: symmetry, anti-symmetry, orthogonality etc.
- eigenvalue problem, theorem of Cayley-Hamilton, invariants; tensors of higher order
- tensor algebra in curvilinear coordinate systems
- tensor analysis in curvilinear coordinate systems
- Differentiation of tensor functions

Application of tensor calculus in strength of materials

- kinematics of infinitesimal and finite deformations
- transport theorem, balance equations, stress tensor
- theory of elasticity
- thermo-elasticity

**Literature**

lecture notes

Bertram, A.: Elasticity and Plasticity of Large Deformations - an Introduction. Springer 2005.

Liu, I-S.: Continuum Mechanics. Springer, 2002.

Schade, H.: Tensoranalysis. Walter de Gruyter, New York, 1997.

Wriggers, P.: Nichtlineare Finite-Element-Methoden. Springer, 2001.

**Course: Mathematical methods of vibration theory [2162241]****Coordinators:** W. Seemann**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

**Learning Control / Examinations**

written or oral exam

Announcement 6 weeks prior to examination date.

**Conditions**

Technische Mechanik III, IV / Engineering Mechanics III, IV

**Learning Outcomes**

The students know to solve single differential equations with constant coefficients by various methods. For inhomogeneous differential equations the inhomogeneity may be arbitrary. They realize the relations between the different methods. For matrix-differential equations the students may derive the eigenvalue problem for free vibration and may obtain solutions for eigenvalues and eigenvectors. They know the modal transformation which is helpful to solve forced vibration. They may decide about stability of time-independent steady state solutions of nonlinear systems. They can derive boundary value problems by variational methods and know in principle how to solve them. For simple one-dimensional continua they may get analytical solutions. They can apply perturbation methods to derive analytical solutions for problems with small parameters.

**Content**

Linear, time-invariant, ordinary single differential equations: homogeneous solution; harmonic, periodic and non-periodic excitations; Duhamel's integral; Fourier and Laplace transform; introduction into the theory of distributions; Systems of ordinary differential equations: matrix notation, eigenvalue theory, fundamental matrix, forced vibrations via modal expansion and transition matrix; Introduction into the dynamic stability theory; Partial differential equations: solution in product form, eigenvalue theory, modal expansion using Ritz series; Variational methods, Hamilton's principle, boundary value problems representing vibrating continua; Perturbation methods

**Literature**

Riemer, Wedig, Wauer: Mathematische Methoden der Technischen Mechanik

**Course: Mathematical Methods in Fluid Mechanics [2154432]****Coordinators:** A. Class, B. Frohnäpfel**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

written

Duration: 3 hours

Aux. means: formules, pocket calculator

**Conditions**

None.

**Recommendations**

Basic Knowledge about Fluid Mechanics

**Learning Outcomes**

The students can to simplify the Navier-Stokes equations for specific flow problems. They are able to employ mathematical method in fluid mechanics effectively in order to solve the resulting conservation equations analytically, if possible, or to enable simpler numerical access to the problem. They can describe the limits of applicability of the assumptions made to model the flow behavior.

**Content**

The lecture will cover a selection of the following topics:

- Curvilinear coordinates and tensor calculus
- Potential flow theory
- Boundary-layer theory
- Laminar-turbulent transition (linear stability theory)
- Turbulent flows
- Numerical solution of the governing equation (finite difference methods)

**Media**

chalk board, Power Point

**Literature**

Kundu, P.K., Cohen, K.M.: Fluid Mechanics, Elsevier, 4th Edition, 2008

Batchelor, G.K.: An Introduction to Fluid Dynamics, Cambridge Mathematical Library, 2000

Boiko, A. V., Grek, G. R., Dovgal, A. V., Kozlov, V. V.: The Origin of Turbulence in Near-Wall Flows, Springer, 2002

Pope, S. B.: Turbulent Flows, Cambridge University Press, 2000

Ferziger, H., Peric, M.: Computational Methods for Fluid Dynamics, Springer, 2008

**Remarks**

The lecture is accompanied by a tutorial (2154433) where the application of the methods can be practised.

**Course: Mathematical Methods in Structural Mechanics [2162280]****Coordinators:** T. Böhlke**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 30: Applied Mechanics (p. 445)[SP\_30\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

**Learning Control / Examinations**

depending on choice according to actual version of study regulations

Additives as announced

Prerequisites are met by solving homework problems

**Conditions**

None.

**Recommendations**

This course is geared to MSc students.

**Learning Outcomes**

The students can

- apply methods of variational calculus for solving problems of linear elasticity
- assess mesoscopic and macroscopic können mesoskopische und makroskopische Spannungs- und Dehnungsmaße beurteilen
- apply and evaluate the methods of homogenization of elastic and thermo-elastic properties
- list methods of homogenization of elastic-plastic properties
- solve worksheet problems to topics of the lecture using technical-mathematical software

**Content**

Basics of variational calculus

- functionals; Frechet-differential; Gateaux-differential; maximum or minimum problems
- lemma of variational calculus and Lagrange delta-process; Euler-Lagrange-equations

Applications: Principals of continuums mechanics

- variational principals in mechanics; variational formulierung of boundary value problem of elastostatic

Applications: Homogenization methods for materials with microstructure

- mesoscopic and macroscopic stress and strain measures
- Mean values of ensembles, ergodicity
- effective elastic properties
- Homogenization of thermo-elastic properties
- Homogenization of plastic and visco-plastic properties
- Fe-based homogenization

**Literature**

Vorlesungsskript

Gummert, P.; Reckling, K.-A.: Mechanik. Vieweg 1994.

Gross, D., Seelig, T.: Bruchmechanik – Mit einer Einführung in die Mikromechanik. Springer 2002.

Klingbeil, E.: Variationsrechnung, BI Wissenschaftsverlag, 1977

Torquato, S.: Random Heterogeneous Materials. Springer, 2002.

**Course: Mathematical models and methods in combustion theory [2165525]****Coordinators:** V. Bykov, U. Maas**Part of the modules:** SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The attendance of this course enables students to:

- apply the fundamental concepts of combustion modelling.
- develop ideal models for the description of auto-ignition, explosions, flame quenching and detonations.
- understand the basic mathematical (asymptotic) methods applied in the analysis of these models.
- perform a mathematical analysis of the models.
- determine the mathematical properties of the solutions obtained from the models.

**Content**

The lecture shall introduce the basics of the mathematical modeling and the analysis of reacting flows. The fundamental methods of the modeling of combustion processes are outlined and asymptotical methods, which deliver reasonable approximations for numerous combustion processes will be applied. Further more examples of simplified models for the description of autoignition, explosions, flame quenching and detonations will be discussed. Furthermore the main analytical methods will be illustrated using simple examples.

**Literature**

Combustion Theory, F A Williams, (2nd Edition), 1985, Benjamin Cummins.

Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation, J. Warnatz, U. Mass and R. W. Dibble, (3rd Edition), Springer-Verlag, Heidelberg, 2003.

The Mathematical Theory of Combustion and Explosions, Ya.B. Zeldovich, G.I. Barenblatt, V.B. Librovich, G.M. Makhviladze, Springer, New York and London, 1985.

**Course: Mathematical models and methods for Production Systems [2117059]****Coordinators:** K. Furmans, J. Stoll**Part of the modules:** SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations**

oral

30min (electives), 60min (main subject)

examination aids: none

**Conditions**

none

**Recommendations**

Basic knowledge of statistic

recommended compulsory optional subject:

- Stochastics in Mecanical Engineering

recommended lecture:

- Material flow in logistic systems (also parallel)

**Learning Outcomes**

Students are able to:

- Describe material flow systems with analytical solvable stochastic models,
- Derive Approches for control systems (KANBAN) based on easy models of queueing theory,
- Execute practical exercised on workstations and
- Use simulation and exakt methods.

**Content**

- single server systems: M/M/1, M/G/1: priority rules, model of failures
- networks: open and closed approximations, exact solutions and approximations
- application to flexible manufacturing systems, AGV (automated guided vehicles) - systems
- modeling of control approaches like constant work in process (ConWIP) or kanban
- discrete-time modeling of queueing systems

**Media**

black board, lecture notes, presentations

**Literature**

Wolff: Stochastic Modeling and the Theory of Queues, Prentice Hall, 1989

Shanthikumar, Buzacott: Stochastic Models of Manufacturing Systems

**Remarks**

none

**Course: Mechanics of laminated composites [2161983]****Coordinators:** E. Schnack**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term |                      |

**Learning Control / Examinations**

Oral examination. Duration: 30 minutes.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

In the first part of the course the students are introduced to the definition of modern composites. The terms 'lamina', 'laminae' and 'laminated' are explained in detail with reference to examples. The students are then able to classify modern composites, particularly when they use these materials to design machine structures. As by definition the material data are directionally dependent, different transformations are discussed so that the students can understand the structural behaviour and participate in the design of the materials.

**Content**

Definition of composites, definition of static and kinematic groups. Definition of material laws. Transformation of the state values of composites and transformation of the material properties for the coordinate systems in the design of machine structures.

**Literature**

Lecture notes (available in the administration office, building 10.91, rm. 310)

**Course: Mechanics and Strengths of Polymers [2173580]****Coordinators:** B. Graf von Bernstorff**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 36: Polymer Engineering (p. 454)[SP\_36\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

Duration: 20 - 30 minutes

no notes

**Conditions**

basic knowledge in materials science (e.g. lecture materials science I and II)

**Learning Outcomes**

The students are prepared to

- repeat the calculus on strength and design of engineering parts exposed to complex loadings,
- estimate the influence of time and temperature on the strength of polymeric materials,
- relate the strength of materials to their molecular structure, morphology and processing parameters and
- derive failure mechanisms for homogenous polymers and composite materials therefrom.

**Content**

Molecular structure and morphology of polymers, temperature- and time dependency of mechanical behavior, viscoelasticity, time/temperature- superposition principle, yielding, crazing and fracture of polymers, failure criterions, impact and dynamic loading, corresponding principle, tough/brittle-transition, introduction to the principles of fiber reinforcement and multiple cracking in composites

**Literature**

A literature list, specific documents and partial lecture notes shall be handed out during the lecture.

**Course: Mechanics in Microtechnology [2181710]****Coordinators:** P. Gruber, C. Greiner**Part of the modules:** SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral exam 30 minutes

**Conditions**

compulsory preconditions: none

**Learning Outcomes**

The students know and understand size and scaling effects in micro- and nanosystems. They understand the impact of mechanical phenomena in small dimensions. Based on this they can judge how they determine material processing as well as working principles and design of microsensors and microactuators.

**Content**

1. Introduction: Application and Processing of Microsystems
2. Scaling Effects
3. Fundamentals: Stress and Strain, (anisotropic) Hooke's Law
4. Fundamentals: Mechanics of Beams and Membranes
5. Thin Film Mechanics: Origin and Role of Mechanical Stresses
6. Characterization of Mechanical Properties of Thin Films and Small Structures: Measurement of Stresses and Mechanical Parameters such as Young's Modulus and Yield Strength; Thin Film Adhesion and Stiction
7. Transduction: Piezo-resistivity, Piezo-electric Effect, Electrostatics,...
8. Actuation: Inverse Piezo-electric Effect, Shape Memory, Electromagnetic Actuation,...

**Literature**

Folien,

1. M. Ohring: „The Materials Science of Thin Films“, Academic Press, 1992
2. L.B. Freund and S. Suresh: „Thin Film Materials“
3. M. Madou: Fundamentals of Microfabrication“, CRC Press 1997
4. M. Elwenspoek and R. Wiegerink: „Mechanical Microsensors“ Springer Verlag 2000
5. Chang Liu: Foundations of MEMS, Illinois ECE Series, 2006

**Course: Laboratory mechatronics [2105014]****Coordinators:** A. Albers, G. Bretthauer, C. Proppe, C. Stiller**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

**Learning Control / Examinations**

Certification of participation or oral examination depending on the "Studienplan" resp. "Prüfungs- und Studienordnung (SPO)" / IPEK: partial examination with grade

**Conditions**

none

**Learning Outcomes**

The student is able to ...

- use his knowledge about mechatronics and microsystems technology to solve a practical problem. The laboratory course comprises simulation, bus communication, measurement instrumentation, control engineering and programming.
- integrate the different subsystems from a manipulator to a working compound system in teamwork.

**Content****Part I**

Control, programming and simulation of robots  
 CAN-Bus communication  
 Image processing / machine vision  
 Dynamic simulation of robots in ADAMS

**Part II**

Solution of a complex problem in team work

**Literature**

Manuals for the laboratory course on Mechatronics

**Course: Human-Machine-Interaction [24659]****Coordinators:** M. Beigl, Takashi Miyaki**Part of the modules:** SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment is explained in the module description.

**Conditions**

None.

**Learning Outcomes**

-

**Content****Literature**

David Benyon: Designing Interactive Systems: A Comprehensive Guide to HCI and Interaction Design. Addison-Wesley Educational Publishers Inc; 2nd Revised edition edition; ISBN-13: 978-0321435330

Steven Heim: The Resonant Interface: HCI Foundations for Interaction Design. Addison Wesley; 1 edition (March 15, 2007) ISBN-13: 978-0321375964

**Course: Measurement Technology [23105]****Coordinators:** F. Puente**Part of the modules:** SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

**Learning Control / Examinations**

Written Exam

**Conditions**

None.

**Recommendations**

Wahrscheinlichkeitstheorie, Komplexe Analysis und Integraltransformationen, Signale und Systeme

**Learning Outcomes**

The goal is to relay theoretical fundamentals.

**Content**

This lecture addresses bachelor students in the fifth semester of Electrical Engineering.

Firstly the terms measurement and characteristic measurement curve are introduced. Possible sources of measurement errors are presented and these errors are classified as either systematic or stochastic. In the course of the lecture, means to reduce both classes of errors are illustrated.

Since the characteristic curve of real world measurement systems is in general not given analytically, it must be derived from a set of given measurements. Therefore basic curve fitting schemes are discussed, including approximation (least squares) and interpolation (Lagrange and Newton polynomial interpolation, spline interpolation) methods.

Another part of the lecture covers the steady-state behaviour of measurement systems. Therefore the ideal characteristic curve, which is assumed for most measurement systems, is introduced and errors that arise hereby are evaluated. Afterwards, concepts to reduce these errors are presented for working both under specified normal conditions and with aberrations thereof.

In order to cope with stochastic measurement errors the basics of probabilistic theory are reviewed in short. As a new instrument to gain information about the unknown probability densities of the observed quantities, samples are introduced. Furthermore, parameter tests and goodness-of-fit tests as statistical hypothesis tests to prove/refute statements about these densities are presented.

As another powerful measurement tool, correlational measurement is subject matter of another part of the lecture and stochastic processes as necessary basics to this are went over in short. Based on it applications for transit time measurement and Doppler measurement are presented. The power-density spectrum is defined as the fourier transform of the correlation function and provides means for system identification. Also the Wiener filter as an optimal filter for signal reconstruction is covered.

Given that processing of real world measurements takes place mostly on digital computers, errors introduced by analogue/digital conversion are discussed for both the time- and amplitude-domain. Therefore the sampling- and quantization-theorem and means to fulfill both of them (anti-aliasing filter, dither) are presented as well as common ADC and DAC converter principles.

**Literature**

Literature: F. Puente León, U. Kiencke, R. Eger; Messtechnik; 8. überarbeitete Auflage 2011. G. Lebelt und F. Puente; Übungsaufgaben zur Messtechnik und Sensorik

**Remarks**

The course comprises of the interleaved lecture blocks and exercises. Current information can be found on the IIIT ([www.iiit.kit.edu](http://www.iiit.kit.edu)) webpage.

**Course: Measurement technique for fluid mechanics [2190913]****Coordinators:** X. Cheng**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations**

- Colloquium
- Documentation

**Conditions**

none

**Learning Outcomes**

The students

- can design the experimental setup and define the measurement parameters for a given specific task
- are able to choose the correct sensors and measurement devices
- exercise performance of experiments and measurement data acquisition
- can analyze and evaluate experimental results
- identify sources for measurement errors perform error analysis

**Content**

- Experimental setup and performance
- Selection and application of measurement techniques
- Introduction of the software LabView for measurement data acquisition
- Introduction of LDA and BSA Flow Software
- Application of OriginPro
- Documentation

**Course: Measurement II [2138326]****Coordinators:** C. Stiller**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination

Duration: 30 minutes

no reference material

**Conditions**

Fundamentals in measurement, system and control theory, e.g. from the lecture "Measurement and Control Systems"

**Learning Outcomes**

The capabilities of modern sensor technology pave the way for novel applications in engineering. Especially digital measurement techniques may be used even in very complex environments and thus have strong impact on technological progress. Stochastic models of measurement processes form the basis for meaningful information processing and provide a valuable tool for engineering. This interdisciplinary lecture addresses students in mechanical engineering and related subjects. The lecture gives an overview of digital technology and stochastics. These areas form the basics of estimation methods that can be embedded elegantly in the theory of state observers. Applications in signal processing for modern environmental perception (video, Lidar, Radar) illustrate the discussed subjects.

**Content**

1. Amplifiers
2. Digital technology
3. Stochastic modeling for measurement applications
4. Estimation
5. Kalman Filter
6. Environmental perception

**Literature**

Various Scripts

**Course: Analysis tools for combustion diagnostics [2134134]****Coordinators:** U. Wagner**Part of the modules:** SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], (p. 475)[SP\_58\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination, Duration: 25 min., no auxiliary means

**Conditions**

none

**Recommendations**

Fundamentals of Combustion Engines helpful

**Learning Outcomes**

The students can name and explain state-of-the-art methods to analyse the process in combustion as well as special measuring techniques such as optical and laser analysis. They are able to thermodynamically model, analyse and evaluate the engine process.

**Content**

energy balance at the engine  
 energy conversion in the combustion chamber  
 thermodynamics of the combustion process

flow velocities

flame propagation

special measurement techniques

**Literature**

Lecture notes available in the lectures

**Course: Methodic Development of Mechatronic systems [2145180]****Coordinators:** A. Albers, W. Burger**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

**Conditions**

none

**Learning Outcomes**

The students ...

- are able to work in an interdisciplinary team for mechatronic system development, to understand the problems of the other subject and to arbitrate in case of misunderstandings.
- have knowledge about the different ways of thinking of mechanical engineers, electrical engineers and computer scientists.
- know the most common technical terms of electrical – and software engineering.
- are able to illustrate typical technical- human- interfaces in the mechatronic field and to identify interactions between mechanical and electrical part systems.

**Content**

Introduction - from market to product

Typical activities during the development of electronic components, traps and problems

Interfaces between mechanics / electronics / software / human user

Typical activities during the development of software, traps and problems

Failure modes and mechanisms of electronic circuits

Failure modes and verification of software

Quality assurance of mechatronic systems

Human interfacing problems, team-management

**Literature**

Manuals for the lecture available

**Course: Methodical Design of Composite Structures [2114101]****Coordinators:** O. Helms**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

written, approx. 90 min

**Conditions**

Maschinenkonstruktionslehre I-III

**Recommendations**

Technische Mechanik I + II

Composites für Lightweight Design

**Learning Outcomes**

Students are enabled to use construction methods needed to develop composite structures. They understand an engineer's tasks and challenges in project management as well as in planning and realizing research- and development-projects.

They understand the use of composites as support structures as well as planning and designing.

**Content**

- construction
- definition of task
- conception
- predimensioning
- designing composite structures
- planning composite production

**Media**

**Literature:** H. Schürmann, Konstruieren mit Faser-Kunststoff-Verbunden : mit ... 39 Tabellen, 2., bearb. und erw.Aufl. ed. Berlin: Springer, 2007.

Cript: O. Helms, Methodisches Konstruieren von Faserverbund-Strukturen, is offered at lecture

**Course: Microenergy Technologies [2142897]****Coordinators:** M. Kohl**Part of the modules:** SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

Oral, 30 minutes

**Conditions**

None.

**Recommendations**

The lecture addresses students in the fields of mechanical engineering, energy technologies, mechatronics and information technology. A comprehensive introduction is given in the basics and current developments in this new and very dynamically evolving field.

The lecture is (supplementary/compulsory) in the master course of „Micro Energy Technologies“ and supplementary in the major of „Mechatronics and Microsystems Technology“ in Mechanical Engineering.

Mechanical Engineering: Major M&amp;M

Energy Technologies: NN

Energietechnik: NN

**Learning Outcomes**

- Knowledge of the principles of energy conversion
- Knowledge of the underlying concepts of thermodynamics and materials science
- Explanation of layout, fabrication and function of the treated devices
- Calculation of important properties (time constants, forces, displacements, power, degree of efficiency, etc.)
- Development of a layout based on specifications

**Content**

- Basic physical principles of energy conversion
- Layout and design optimization
- Technologies
- Selected devices
- Applications

The lecture includes amongst others the following topics:

Micro energy harvesting of vibrations

Thermal micro energy harvesting

Microtechnical applications of energy harvesting

Heat pumps in micro technology

Micro cooling

**Literature**

- Lecture notes (overhead transparencies) „Micro Energy Technologies“
- Stephen Beeby, Neil White, Energy Harvesting for Autonomous Systems, Artech House, 2010
- Shashank Priya, Daniel J. Inman, Energy Harvesting Technologies, Springer, 2009

**Course: Microoptics and Lithography [2142884]****Coordinators:** T. Mappes**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

oral, duration 20 minutes, aids: none

**Conditions**

Basics in optics

**Learning Outcomes****Content**

**Course: Microactuators [2142881]****Coordinators:** M. Kohl**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

(1) as core subject in the major "Actuators and Sensors" combined with the core subject "New Actuators and Sensors", oral, 60 minutes

or

(2) as optional subject, oral, 30 minutes

**Conditions**

None.

**Recommendations**

The lecture addresses students in the fields of mechanical engineering, mechatronics and information technology, materials science and engineering, electrical engineering and economic sciences. A comprehensive introduction is given in the basics and current developments on the microscopic length scale.

The lecture is core subject of the major course "Actuators and Sensors" of the specialization "Mechatronics and Microsystems Technology" in Mechanical Engineering.

Mechanical Engineering: Specialization M&M / Major 54

**Learning Outcomes**

- Knowledge of the actuation principles including pros and cons
- Knowledge of important fabrication technologies
- Explanation of layout and function of the microactuators
- Calculation of important properties (time constants, forces, displacements, etc.)
- Development of a layout based on specifications

**Content**

- Basic knowledge in the material science of the actuation principles
- Layout and design optimization
- Fabrication technologies
- Selected developments
- Applications

The lecture includes amongst others the following topics:

- Microelectromechanical systems: linear actuators, microrelais, micromotors
- Medical technology and life sciences: Microvalves, micropumps, microfluidic systems
- Microrobotics: Microgrippers, polymer actuators (smart muscle)
- Information technology: Optical switches, mirror systems, read/write heads

**Literature**

- Lecture notes
- D. Jendritza, Technischer Einsatz Neuer Aktoren: Grundlagen, Werkstoffe, Designregeln und Anwendungsbeispiele, Expert-Verlag, 3. Auflage, 2008
- M. Kohl, Shape Memory Microactuators, M. Kohl, Springer-Verlag Berlin, 2004
- N.TR. Nguyen, S.T. Wereley, Fundamentals and applications of Microfluidics, Artech House, Inc. 2002
- Y. Bar-Cohen, Electroactive Polymer (EAP) Actuators as Artificial Muscles, SPIE – The International Society for Optical Engineering, 2004

**Course: Microstructure characterization and modelling [2161251]****Coordinators:** T. Böhlke, F. Fritzen**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

**Conditions**

None.

**Recommendations**

This course is geared to MSc students.

**Learning Outcomes**

The students can

- 
- list, apply and evaluate basic measures to describe the geometry of microstructured materials
- choose appropriate distribution functions for describing fibre or particle reinforced or polycrystalline materials
- list and evaluate the basic steps of algorithms for generation of synthetic structures

**Content**

An introduction to the statistical description of geometric properties of microstructured materials is given. Typically, particle or fibre reinforced materials and polycrystalline materials are considered. The statistical description using n-point-correlation functions is described as well as characteristic measures and distribution functions (fibre or crystal orientation distribution functions) are discussed. Additionally, methods for generation of synthetic structures are considered which are typical input data for numerical multiscale simulations.

**Literature**

Torquato, S.: Random heterogeneous materials: microstructure and macroscopic properties, Springer, New York, 2002.

Ohser, J., Mücklich, F.: Statistical Analysis of Microstructures in Materials Science, Statistics in Practice, John Wiley & Sons, 2000.

**Course: Modelling of Microstructures [2183702]****Coordinators:** A. August, B. Nestler, D. Weygand**Part of the modules:** SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Winter term | de                   |

**Learning Control / Examinations**

We regularly hand out exercise sheets. The individual solutions will be corrected.

Exam: oral 30 minutes or written.

**Conditions**

None.

**Recommendations**

materials science  
fundamental mathematics

**Learning Outcomes**

The student can

- explain the thermodynamic and statistical foundations for liquid-solid and solid-solid phase transition processes and apply them to construct phase diagrams.
- describe the specific characteristics of dendritic, eutectic and peritectic microstructures.
- explain the mechanisms of grain and phase boundary motion induced by external fields
- use the phase-field method for simulation of microstructure formation processes using modeling approaches and challenges of current research
- has experiences in computing and conduction simulations of microstructure formation from an integrated computer lab.

**Content**

- Brief Introduction in thermodynamics
- Statistical interpretation of entropy
- Gibbs free energy and phase diagrams
- Free energy functional
- Phasefield equation
- Gibbs-Thomson-equation
- Driving forces
- Grand chemical potential functional and the evolution equations
- For compare: Free energy functional with driving forces

**Media**

Black board and slides.

**Literature**

1. Gottstein, G. (2007) Physikalische Grundlagen der Materialkunde. Springer Verlag Berlin Heidelberg

2. Kurz, W. and Fischer, D. (1998) Fundamentals of Solidification. Trans Tech Publications Ltd, Switzerland Germany UK USA
3. Porter, D.A. Eastering, K.E. and Sherif, M.Y. (2009) Phase transformation in metals and alloys (third edition). CRC Press, Taylor & Francis Group, Boca Raton, London, New York
4. Gaskell, D.R., Introduction to the thermodynamics of materials
5. Problem sheets

**Course: Mobile Machines [2114073]****Coordinators:** M. Geimer**Part of the modules:** SP 34: Mobile Machines (p. 451)[SP\_34\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Summer term | de                   |

**Learning Control / Examinations**

oral examination.

**Conditions**

Knowledge in Fluid Power is required.

**Recommendations**It is recommended to attend the course *Fluid Power Systems* [2114093] beforehand.**Learning Outcomes**

After completion of the course the students have knowledge of:

- a wide range of mobile machines
- operation modes and working cycles of important mobile machines
- selected subsystems and components

**Content**

- Introduction of the required components and machines
- Basics of the structure of the whole system
- Practical insight in the development techniques

**Media**

Lecture notes.

**Course: Model based Application Methods [2134139]****Coordinators:** F. Kirschbaum**Part of the modules:** (p. 475)[SP\_58\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term |                      |

**Learning Control / Examinations**

take-home exam, short presentation with oral examination

**Conditions**

none

**Recommendations**

knowledge in Basics of combustion engines, vehicular systems, control theorie and statistics.

**Learning Outcomes**

The student can name the most important methods for model-based calibration of powertrain ECUs. Particulary he can choose and apply the correct approach for empirical modeling for a given powertrain calibration task (fuel consumption, emissions, air path, driveability, etc.) and type of plant (linear-nonlinear, static-dynamic, etc.). He is capable to solve typical Problems of a calibration engineer of automotive OEMs or suppliers.

**Content**

The efforts for the calibration of automotive powertrain ECUs are increasing due to new engine or powertrain technologies and tightening emission laws. From a present view only model based calibration methods are capable to handle this situation. The lecture presents a selection of practice-proofed model-based calibration methods.

**Media**

Lecture notes, blackboard, presentations and life demonstrations via projector

**Course: Modeling of Thermodynamical Processes [2167523]****Coordinators:** R. Schießl, U. Maas**Part of the modules:** SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 6            | 3              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

After completing the course the students are able to:

- formulate thermodynamical basics in a mathematical scheme.
- abstract and model complex thermodynamic processes.
- determine and implement adequate numerical schemes for the solution of the resulting systems of equations.

**Content**

Thermodynamic basics

Numerical solver strategies for algebraic equations

Optimization issues

Ordinary and partial differential equations

Application to various problems in thermodynamics (engine processes, determination of equilibrium states, unsteady processes in inhomogeneous systems)

**Literature**

Lecture notes

Numerical Recipes {C, FORTRAN}; Cambridge University Press

R.W. Hamming; Numerical Methods for scientists and engineers; Dover Books On Engineering; 2nd edition; 1973

J. Kopitz, W. Polifke; Wärmeübertragung; Pearson Studium; 1. Auflage

**Course: Modelling and Simulation [2183703]****Coordinators:** B. Nestler, P. Gumbsch**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 5            | 3              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

We regularly hand out exercise sheets. In addition, the course will be accompanied by practical exercises at the computer.

written examination: 90 minutes

**Conditions**

None.

**Recommendations**

preliminary knowlegde in mathematics, physics and materials science

**Learning Outcomes**

The student can

- explain the basic algorithms and numerical methods which are beside other applications relevant for materials simulations.
- describe and apply numerical solution methods for partial differential equations and dynamical systems
- apply numerical methods to solve heat and mass diffusion problems which can also be used to model microstructure formation processes
- has experiences in how to implement and program the introduced numerical methods from an integrated computer lab.

**Content**

The course gives an introduction to modelling and simulation techniques.

The following topics are included:

- splines, interpolation methods, Taylor series
- finite difference method
- dynamical systems
- numerics of partial differential equations
- mass and heat diffusion
- microstructure simulation
- parallel and adaptive algorithms
- high performance computing
- practical exercises

**Media**

Slides and black board. The slides will be provided as a manuscript for the course.

**Literature**

1. Scientific Computing, G. Golub and J.M. Ortega (B.G.Teubner Stuttgart 1996)

**Course: [2158206]****Coordinators:** F. Schmidt**Part of the modules:** SP 55: Energy Technology for Buildings (p. 473)[SP\_55\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations****Conditions**

Can not be combined with the lecture Building Simulation [2157109]

**Learning Outcomes****Content**

**Course: Modern Control Concepts I [2105024]****Coordinators:** L. Gröll**Part of the modules:** SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral exam (after lecture period)

**Conditions**

none

**Recommendations**

Measurement and control systems

**Learning Outcomes**

After completion this lecture, the students are able

- to analyse linear systems with respect to different properties,
- to design linear feedback systems with feedforward add-on in time and frequency domain under consideration of input saturation, time delay, unmeasurable states and couplings between system parts,
- to use Matlab for simulation, analysis and synthesis in numerical and computer algebraic way,
- to realise controllers per software in practice

**Content**

1. Introduction (classification, overviews, model simplification)
2. Simulation and analysis of dynamical systems with Matlab
3. Linearisation (equilibrium manifold, low-delta-method, Hartman-Grobman-theorem, design methodology for linear setpoint controller)
4. Two-degree-of-freedom control (structure, reference signal design)
5. PID-Controller (practical realisation, design hints, anti-windup-methods, Smith-predictor, switching technics, complex example)
6. Multi variable control and advanced control structures
7. State space (geometric view, role of zeros)
8. Tracking control with state feedback and supplemental integrator
9. Observer (LQG-design, disturbance observer, reduced observer)
10. Limits of control (existence subject, limits in time and frequency domain)

**Literature**

- Aström, K.-J., Murray, R.M.: Feedback Systems, 2012
- Rugh, W.: Linear System Theory. Prentice Hall, 1996

**Course: Engine Laboratory [2134001]****Coordinators:** U. Wagner**Part of the modules:** (p. 475)[SP\_58\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

written documentation of every experiment, certificate of successful attendance, no grading

**Conditions**

Fundamentals of Combustion Engines I attended

**Learning Outcomes**

The students are able to transfer their theoretical knowledge to practical problems and to perform engine tests on state-of-the-art test benches.

**Content**

5 engine experiments in up-to-date development projects

**Literature**

Description of experiments

**Course: Engine measurement techniques [2134137]****Coordinators:** S. Bernhardt**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], (p. 475)[SP\_58\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination, Duration: 0,5 hours, no auxiliary means

**Conditions**

None.

**Recommendations**

Combustion Engines A or Fundamentals of Combustion Engines I helpful

**Learning Outcomes**

The students are able to explain the principles of modern measuring devices and are able to determine the right device for a certain measuring problem. They are able to analyse and evaluate the results.

**Content**

Students get to know state-of-the-art measurement techniques for combustion engines. In particular basic techniques for measuring engine operating parameters such as torque, speed, power and temperature.

Possible measurement errors and aberrations are discussed.

Furthermore techniques for measuring exhaust emissions, air/fuel ratio, fuel consumption as well as pressure indication for thermodynamic analysis are covered.

**Literature**

Lecture notes available in the lectures or in the 'Studentenhaus'

1. Grohe, H.: Messen an Verbrennungsmotoren
2. Bosch: Handbuch Kraftfahrzeugtechnik
3. Veröffentlichungen von Firmen aus der Meßtechnik
4. Hoffmann, Handbuch der Meßtechnik
5. Klingenberg, Automobil-Meßtechnik, Band C

**Course: Multilingual Human-Machine Communication [24600]****Coordinators:** T. Schultz, F. Putze**Part of the modules:** SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Summer term | de                   |

**Learning Control / Examinations**

The assessment is explained in the module description.

**Conditions**

None.

**Learning Outcomes**

The students will be introduced to the foundations of automatic speech recognition and processing. The lecture begins with the theoretical background on signal processing and models of speech production and perception. The focus here is on statistical methods. The current state of the art is presented using many real-world applications. After attending the lecture, students should be able to assess the potential as well as the challenges and limitations of modern speech technology and applications.

**Content**

The lecture offers an introduction to the foundations of automatic speech recognition and processing. The lecture begins with the theoretical background on signal processing and models of speech production and perception. The focus here is on statistical methods. Then, the central approaches and methods for a successful transition from theory to practice are presented. The current requirements for speech recognition and processing regarding globalization and multilingualism are illustrated using several examples of state of the art systems.

For further information, see <http://csl.anthropomatik.kit.edu>.

**Media**

slides (online at <http://csl.anthropomatik.kit.edu>)

**Literature****Elective literature:**

Xuedong Huang, Alex Acero und Hsiao-wuen Hon, Spoken Language Processing, Prentice Hall PTR, NJ, 2001  
 Tanja Schultz und Katrin Kirchhoff (Hrsg.), Multilingual Speech Processing, Elsevier, Academic Press, 2006

**Remarks**

Language of the lecture: German (English by request)

## Course: Nanotechnology for Engineers and Natural Scientists [2142861]

**Coordinators:** H. Hölscher, M. Dienwiebel, S. Walheim

**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 47: Tribology (p. 466)[SP\_47\_mach], SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

The successful attendance of the lecture is controlled by a 30 minutes written examination, and a subsequent oral examination (20 min). Passing the written exam is mandatory for the participation of the oral examination. The grade result is the result of the oral exam.

### Conditions

preliminary knowledge in mathematics and physics

### Learning Outcomes

The student can

- explain the most common measurement principles of nanotechnology especially scanning probe methods and is able to use them for the characterisation of chemical and physical properties of surfaces
- describe interatomic forces and their influence on nanotechnology
- describe methods of micro- and nanofabrication and of –nanolithography
- explain simple models used in contact mechanics and nanotribology
- describe basic concepts used for nanoscale components

### Content

- 1) Introduction into nanotechnology
- 2) History of scanning probe techniques
- 3) Scanning tunneling microscopy (STM)
- 4) Atomic force microscopy (AFM)
- 5) Dynamic Modes (DFM, ncAFM, MFM, KPFM, ...)
- 6) Friction force microscopy & nanotribology
- 7) Nanolithography
- 8) Other families of the SPM family

### Literature

1. Lecture notes, slides, script
2. Scanning Probe Microscopy – Lab on a Tip: Meyer, Hug, Bennewitz, Springer (2003)

**Course: Nanotechnology with Clusterbeams [2143876]****Coordinators:** J. Gspann**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

written examination

presence in more than 70% of the lectures

Duration: 1 h

aids: none

**Conditions**

None.

**Learning Outcomes**

Nanotechnology is presented on the basis of a technology for nano- and microstructuring by accelerated nanoparticles (clusters), mainly in view of nanomechanics.

**Content**

Nanotechnology in biology

Nanosystemstechnology

Cluster beam generation, ionisation and acceleration; cluster properties

Structure generation using accelerated metal clusters

Structuring via gas cluster impact; reactive accelerated cluster erosion (RACE)

Atomic force microscopy of impact structures; nanotribology

Comparison with femtosecond laser machining (Winter term only)

Simulations; Fullerene synthesis, impact structures, visionary nanomachinery

**Literature**

Foil copies with short commentaries are distributed during the lectures.

**Course: Nanotribology and -Mechanics [2181712]**

**Coordinators:** M. Dienwiebel, H. Hölscher  
**Part of the modules:** SP 47: Tribology (p. 466)[SP\_47\_mach]

| ECTS Credits | Hours per week | Term | Instruction language |
|--------------|----------------|------|----------------------|
| 4            | 2              |      |                      |

**Learning Control / Examinations**

presentation (40%) and oral examination (30 min, 60%)

no tools or reference materials

**Conditions**

preliminary knowlegde in mathematics and physics

**Learning Outcomes**

The student can

- explain the physical foundations and common models used in the field of nanotribology and nanomechanics
- describe the most important experimental methods in nanotribology
- critically evauate scientific papers on nanotribological issues with respect to their substantial quality

**Content**

Part 1: Basics:

- Nanotechnology
- Forces at nanometer scale
- contact mechanics models (Hertz, JKR, DMT)
- Experimental methods (SFA, QCM, FFM)
- Prandtl-Tomlinson model
- Superlubricity
- Atomic-Scale Wear

Part 2: Topical papers

**Literature**

Lecture notes, slides and copies of articles

**Course: Novel actuators and sensors [2141865]****Coordinators:** M. Kohl, M. Sommer**Part of the modules:** SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content****Literature**

- Sensoren: "Sensors Update", Volumes 1 und 2, Edited by H. Baltes, W.Göpel, J.Hesse, VCH, 1996, ISBN 3-527-29432-5
- Nanofasern: "Nanowires and Nanobelts", Volume 2: Nanowires and Nanobelts of Functional Materials, Zhong Lin Wang, 2006, Springer, ISBN 10 0-387-28706-X

**Course: Neutron physics of fusion reactors [2189473]****Coordinators:** U. Fischer**Part of the modules:** SP 53: Fusion Technology (p. 471)[SP\_53\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

The aim of this lecture is to provide the neutron physics principles required for analysis of nuclear fission and fusion reactors. First of all, the basic nuclear interaction processes are presented which are important for the physical behaviour of the reactors. Next the neutron transport phenomenon in matter is described by means of the Boltzmann transport equation. Suitable mathematical solution methods are presented such as the diffusion approximation for nuclear fission reactors and the Monte Carlo method for fusion reactors. The knowledge acquired will eventually be used to solve neutron physics problems related to the design and optimization of the reactors.

**Content**

Nuclear interaction processes and energy release

Chain reaction and criticality

Neutron transport, Boltzmann equation

Diffusion approximation, Monte Carlo method

Neutronic reactor design

**Literature**

K. H. Beckurts, K. Wirtz, Neutron Physics, Springer Verlag, Berlin, Germany (1964)

W. M. Stacey, Nuclear Reactor Physics, John Wiley & Sons, Wiley-VCH, Berlin(2007)

J. Raeder (Ed.), Kontrollierte Kernfusion. Grundlagen ihrer Nutzung zur Energieversorgung, Teubner, Stuttgart (1981)

**Course: Nonlinear Continuum Mechanics [2162344]****Coordinators:** T. Böhlke**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 56: Advanced Materials Modelling (p. 474)[SP\_56\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 2              | Summer term | en                   |

**Learning Control / Examinations**

oral examination

**Conditions**

None.

**Recommendations**

This course is geared to MSc students.

**Learning Outcomes**

The students can

- derive the kinematics of finite deformations
- derive the balance laws in regular and irregular points
- discuss the principles of material theory for given examples
- evaluate the basics of finite elasticity
- discuss the basics of elasto-plasticity
- apply basic concepts of crystal plasticity to example problems

**Content**

- tensor calculus, kinematics, balance equations
- principles of material theory
- finite elasticity
- infinitesimal elasto(visco)plasticity
- exact solutions of infinitesimal plasticity
- finite elasto(visco)plasticity
- infinitesimal and finite crystal(visco)plasticity
- hardening and failure
- strain localization

**Literature**

lecture notes

Bertram, A.: Elasticity and Plasticity of Large Deformations - an Introduction. Springer 2005.

Liu, I-S.: Continuum Mechanics. Springer 2002.

Schade, H.: Tensoranalysis. Walter de Gruyter 1997.

Wriggers, P.: Nichtlineare Finite-Element-Methoden. Springer 2001.

**Course: Nuklear Medicine and Nuklear Medicine Measurement Technics I [23289]****Coordinators:** F. Maul, H. Doerfel**Part of the modules:** SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Winter term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (approx. 20 minutes) according to sec. 4 subsec. 2 no. 2 study and examination regulations.

**Conditions**

None.

**Learning Outcomes**

Die Studenten kennen den Zusammenhang zwischen klinischen Problemen und deren messtechnischen Lösung aufgrund von nuklearmedizinischen Beispielen aus der Funktionsdiagnostik und Therapie.

**Content**

**Course: Numerical Mathematics [01874]****Coordinators:** C. Wieners, Neuß, Rieder**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Written examination, duration 3 hours

**Conditions**

None.

**Learning Outcomes**

Die Studierenden kennen nach dieser Vorlesung die Umsetzung des im Mathematik-Modul erarbeiteten Wissens in die zahlenmäßige Lösung praktisch relevanter Fragestellungen. Dies ist ein wichtiger Beitrag zum tieferen Verständnis sowohl der Mathematik als auch der Anwendungsprobleme.

Im Einzelnen können die Studierenden

1. entscheiden, mit welchen numerischen Verfahren sie mathematische Probleme numerisch lösen können,
2. das qualitative und asymptotische Verhalten von numerischen Verfahren beurteilen und
3. die Qualität der numerischen Lösung kontrollieren.

**Content**

- Gleitkommarechnung
- Kondition mathematischer Probleme
- Vektor- und Matrixnormen
- Direkte Lösung linearer Gleichungssysteme
- Iterative Lösung linearer Gleichungssysteme
- Lineare Ausgleichsprobleme
- Lineare Eigenwertprobleme
- Lösung nichtlinearer Probleme: Fixpunktsatz, Newton-Verfahren
- Polynominterpolation
- Fouriertransformation (optional)
- Numerische Quadratur
- Numerische Lösung gewöhnlicher Differentialgleichungen (optional)

**Literature****Elective literature:**

- lecture notes (N. Neuß)
- W. Dahmen/A. Reusken: Numerik für Ingenieure und Naturwissenschaftler

**Course: Numerical mechanics for industrial applications [2162298]****Coordinators:** E. Schnack**Part of the modules:** SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination. Duration: 30 minutes.

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Variation principles are derived in detail on the basis of the principles of virtual work. This provides students with the fundamental knowledge necessary to construct calculus of variations as a basis for numerical mechanics, and consequently derive fundamental equations for finite element methods (FEM) and boundary element methods (BEM). In the lectures, the algorithms for higher-grade finite element processes are deduced, and the numerics for boundary element methods (BEM) are derived in detail. Students will develop an understanding for Cauchy principle values, and the integration of singular integrals will be carried out. In addition, derived methods will be extended to tasks such as plasticity. Numerical mechanics I is not a requirement for Numerical mechanics II. At the end of the course students will be able to derive algorithms for FEM and BEM independently, and evaluate short codes, so that they are better able to manage industrial software.

**Content**

Brief overview of finite element methods. Structure of boundary element methods (BEM). Explanation of hybrid tension methods. Higher-grade finite element processes. Non-linear FEM processes.

**Literature**

Script (available in administration office, building 10.91, rm. 310).

**Course: Computational Methods in Fluid Mechanics [2157441]****Coordinators:** F. Magagnato**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes

No tools or reference materials may be used during the exam.

**Conditions**

none

**Learning Outcomes**

The students can describe the modern numerical simulation methods for fluid flows and can explain their relevance for industrial projects. They can choose appropriate boundary and initial conditions as well as turbulence models. They are qualified to explain the meaning of suitable meshes for processed examples. Convergence acceleration techniques like multi grid, implicit methods etc. as well as the applicability of these methods to parallel and vector computing can be described by the students. They can identify problems that occur during application of these methods and can discuss strategies to avoid them. The students are qualified to apply commercial codes like Fluent, Star-CD, CFX etc. as well as the research code SPARC. They can describe the differences between conventional methods (RANS) and more advanced approaches like Large Eddy Simulation (LES) and Direct Numerical Simulation (DNS).

**Content**

1. Governing Equations of Fluid Dynamics
2. Discretization
3. Boundary and Initial conditions
4. Turbulence Modelling
5. Mesh Generation
6. Numerical Methods
7. LES, DNS and Lattice Gas Methods
8. Pre- and Postprocessing
9. Examples of Numerical Methods for Industrial Applications

**Media**

"Powerpoint presentation", Beamer

**Literature**

Ferziger, Peric: Computational Methods for Fluid Dynamics. Springer-Verlag, 1999.

Hirsch: Numerical Computation of Internal and External Flows. John Wiley &amp; Sons Inc., 1997.

Versteg, Malalasekera: An introduction to computational fluid dynamics. The finite volume method. John Wiley &amp; Sons Inc., 1995

**Course: Numerical Modeling of Multiphase Flows [2130934]****Coordinators:** M. Wörner**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination (in German or English language)

Duration: 30 minutes

Auxiliary means: none

**Conditions**

Bachelor

**Learning Outcomes**

The students can describe the physical fundamentals of multiphase flows (with focus on gas-liquid flows). The students are qualified to select for multiphase flow applications in energy and process engineering appropriate numerical methods and physical models, and to thoroughly evaluate the simulation results, so as to analyze the specific advantages, disadvantages and restrictions of each method.

**Content**

1. Introduction in the subject of multi-phase flows (terms and definitions, examples)
2. Physical fundamentals (dimensionless numbers, phenomenology of single bubbles, conditions at fluid interfaces, forces on a suspended particle)
3. Mathematical fundamentals (governing equations, averaging, closure problem)
4. Numerical fundamentals (discretization in space and time, truncation error and numerical diffusion)
5. Models for interpenetrating continua (homogeneous model, algebraic slip model, standard two-fluid model and its extensions)
6. Euler-Lagrange model (particle equation of motion, particle response time, one-/two-/four-way coupling)
7. Interface resolving methods (volume-of-fluid, level-set and front-capturing method)

**Literature**A brief script can be downloaded from <http://bibliothek.fzk.de/zb/berichte/FZKA6932.pdf>.

Powerpoint presentations can be downloaded after each lecture from the ILIAS system.

A list of recommended books is provided in the first lecture.

**Remarks**

For some topics of the lecture exercises are provided (working on them is optional).

**Course: Numerical simulation of reacting two phase flows [2169458]****Coordinators:** R. Koch**Part of the modules:** SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral exam

Duration: approximately 30 minutes

no tools or reference materials are allowed

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students have the ability to:

- describe and apply the governing equations of fluid mechanics
- select and judge appropriate methods for predicting turbulent flows
- explain the procedures of numerical solver algorithms
- judge the numerical methods, on which common CFD software is based
- judge and apply different approaches to characterize sprays
- apply methods for predicting the break up of liquids
- analyse and evaluate methods and models for the calculation of multiphase flows
- describe reactive flows and the corresponding models

**Content**

The course is devoted to diploma/master students and doctoral candidates of mechanical and chemical engineering. It gives an overview of the numerical methods used for CFD of single and two phase flows. The course introduces methods for reacting single and two phase flows, as they are typically found in gas turbines and piston engines operated by liquid fuel.

1. Single phase flow: Basic equations of fluid dynamics, Turbulence: DNS, LES, RANS; Finite volume methods, Numerical solvers.

2. Two phase flows: Basics of atomisation, Characterisation of sprays, Numerical prediction of droplet movement, Numerical methods for predicting of liquid disintegration (VoF, SPH), Numerical methods for secondary atomisation; Droplet evaporation

3. Reacting flows: Combustion models; Single droplet combustion, Spray combustion.

**Literature**

Lecture notes

**Course: Numerical Simulation of Turbulent Flows [2154449]****Coordinators:** G. Grötzbach**Part of the modules:** SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

oral;

Duration: 30 minutes

no auxiliary means

**Conditions**

None.

**Recommendations**

basics in fluid mechanics

**Learning Outcomes**

The students are qualified to describe the fundamentals of direct numerical simulation (DNS) and large eddy simulation (LES) of turbulent flows and contrast the respective properties to those of conventional turbulence modelling approaches. They can describe subgrid scale models, peculiarities of wall modelling, suitable numerical solution schemes and evaluation methods. They have obtained the knowledge required to identify the best modelling approach (among the available methods) for the problem at hand, thus being able to solve given thermal and fluid dynamical problems appropriately.

**Content**

The lecture series will introduce in following subjects of the turbulence simulation method:

- Appearance of turbulence and deduction of requirements and limits of the simulation method.
- Conservation equations for flows with heat transfer, filtering them in time or space.
- Some subgrid scale models for small scale turbulence and their physical justification.
- Peculiarities in applying boundary and initial conditions.
- Suitable numerical schemes for integration in space and time.
- Statistical and graphical methods to analyse the simulation results.
- Application examples for turbulence simulations in research and engineering

**Media**

black board, plus pictures, movies, and script in English (distributed chapter by chapter)

**Literature**

J. Piquet, *Turbulent Flows – Models and Physics*  
Springer, Berlin (2001)

G. Grötzbach, *Revisiting the Resolution Requirements for Turbulence Simulations in Nuclear Heat Transfer*.  
Nuclear Engineering & Design Vol. 241 (2011) pp. 4379-4390

P. Sagaut, C. Meneveau, *Large-eddy simulation for incompressible flows: An introduction*.  
Springer Verlag (2010)

G. Grötzbach, Script in English

**Course: Numerical Fluid Mechanics with MATLAB [2154409]****Coordinators:** B. Frohnäpfel**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Homework

**Conditions**

None.

**Recommendations**

Lecture "Mathematical Methods of Fluid Mechanics" or "Fluid-Structure-Interaction"

**Learning Outcomes**

Students can goal-oriented solve numerically flow problems. They develop own solvers for characteristic flow scenarios with Matlab. The students abstract the flow problems and distinguish different schemes. They are qualified to adjust relevant settings and solve of the system of equations in Matlab. Furthermore, the students have the ability to evaluate the modeling in combination with the numerical schemes. Particular knowledge in grid resolution independency, stability criteria and how to carry out a validation and verification qualifies the students to analyse und evaluate the quality of flow simulations.

**Content**

Numerical Fluid Mechanics with Matlab

- Introduction to Numerics and Matlab
- Finite-Difference-Method
- Finite-Volume-Method
- boundary conditions and intial conditions
- explicit and implicite schemes
- pressure correction

**Media**

Power Point, workstations: independent programming

**Literature**H. Ferziger, M. Peric, *Computational Methods for Fluid Dynamics*, Springer, 2008**Remarks**

Block course with limited number of participants, registration in the secretary's office required. See details at [www.istm.kit.edu](http://www.istm.kit.edu)

## Course: Intellectual Property Rights and Strategies in Industrial Companies [2147161]

**Coordinators:** F. Zacharias

**Part of the modules:** SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 20: Integrated Product Development (p. 432)[SP\_20\_mach], SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], (p. 475)[SP\_58\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

### Learning Control / Examinations

oral exam

### Conditions

none

### Learning Outcomes

The students understand and are able to describe the basics of intellectual property, particularly with regard to the filing and obtaining of property rights. They can name the criteria of project-integrated intellectual property management and strategic patenting in innovative companies. Students are also able to describe the key regulations of the law regarding employee invention and to illustrate the challenges of intellectual properties with reference to examples.

### Content

The lecture will describe the requirements to be fulfilled and how protection is obtained for patents, design rights and trademarks, with a particular focus on Germany, Europe and the EU. Active, project-integrated intellectual property management and the use of strategic patenting by technologically oriented companies will also be discussed. Furthermore, the significance of innovations and intellectual property for both business and industry will be demonstrated using practical examples, before going on to consider the international challenges posed by intellectual property and current trends in the sector.

Within the context of licensing and infringement, insight will be provided as to the relevance of communication, professional negotiations and dispute resolution procedures, such as mediation for example. The final item on the agenda will cover those aspects of corporate law that are relevant to intellectual property.

Lecture overview:

1. Introduction to intellectual property
2. The profession of the patent attorney
3. Filing and obtaining intellectual property rights
4. Patent literature as a source of knowledge and information
5. The law regarding employee inventions
6. Active, project-integrated intellectual property management
7. Strategic patenting
8. The significance of intellectual property
9. International challenges and trends
10. Professional negotiations and dispute resolution procedures
11. Aspects of corporate law

**Course: Photovoltaics [23737]****Coordinators:** M. Powalla**Part of the modules:** SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Summer term |                      |

**Learning Control / Examinations**

Tutorials, written exams, alternatively oral exam.

**Conditions**

Basic knowledge of thermodynamics and solid state physics.

**Recommendations**

Complement to "Energy Systems" and "Fundamentals of Energy Technology".

**Learning Outcomes**

After the course attendants can:

- understand energy conversion in semiconductors.
- discuss emerging technological and production relevant aspects.
- capture the interaction of photovoltaic energy systems with different system components.
- quantify losses.

**Content**

- The significance of photovoltaics in national and global energy supply.
- Physical fundamentals of energy conversion.
- Photovoltaic cells (specific parameters, materials, loss assessment).
- Implementation concepts (Silicon technology, thin layer cells, concentrator cells, dye cells and organic cells).
- Modular technique and production technology.
- Photovoltaic energy systems (Components, alternative current converter, solar tracking, system design).

**Literature**

P. Würfel, Physik der Solarzellen, 2. Auflage (Spektrum Akademischer Verlag, Heidelberg, 2000)

R. Sauer, Halbleiterphysik, (Oldenburg Wissenschaftsverlag, 2009)

H.J. Lewerenz, H. Jungblut, Photovoltaik (Springer, Berlin, 1995)

H.G. Wagemann, Photovoltaik, (Vieweg, Wiesbaden, 2010)

Tom Markvart, Luis Castaner, Photovoltaics Fundamentals and Applications, (Elsevier, Oxford, 2003)

Heinrich Häberlin, Photovoltaik, (AZ Verlag, Aarau, 2007)

**Course: [2189906]****Coordinators:** R. Dagan, Dr. Volker Metz**Part of the modules:** SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Winter term | de                   |

**Learning Control / Examinations**

oral exam, 20 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The students

- understand the physical explanations of the known nuclear accidents
- can perform simplified calculations to demonstrate the accidents outcome.
- Define safety relevant properties of low/ intermediate / high level waste products
- Are able to evaluate principles and implications of reprocessing, storage and disposal options for nuclear waste.

**Content**

- Relevant physical terms of nuclear physics
- Decay heat removal- Borst-Wheeler equation
- The accidents in TMI- Three Mile Island, and Fukushima .
- Fission , chain reaction and reactor control systems
- Basics of nuclear cross sections
- Principles of reactor dynamics
- Reactor poisoning
- The Idaho and Chernobyl accidents
- Principles of the nuclear fuel cycle
- Reprocessing of irradiated fuel elements and vitrification of fission product solutions
- Interim storage of nuclear residues in surface facilities
- Multi barrier concepts for final disposal in deep geological formations
- The situation in the repositories Asse II, Konrad and Morsleben

**Literature**

AEA- Open documentation of the reactor accidents

K. Wirtz: Basics of Reactor technic Par I, II, Technic School Karlsruhe 1966 (in German)

D. Emendorfer. K.H. Höcker: Theory of nuclear reactions, Parts I, II BI- Hochschultaschenbücher 1969 ( in German)

J. Duderstadt and L. Hamilton: Nuclear reactor Analysis, J. Wiley \$ Sons , Inc. 1975.

R.C. Ewing: The nuclear fuel cycle: a role for mineralogy and geochemistry. Elements vol. 2, p.331-339, 2006

J. Bruno, R.C. Ewing: Spent nuclear fuel. Elements vol. 2, p.343-349, 2006

## Course: Planning of Assembly Systems (in German) [2109034]

**Coordinators:** E. Haller

**Part of the modules:** SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach], SP 37: Production Management (p. 455)[SP\_37\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

### Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

### Recommendations

- Knowledge of Human Factors Engineering or Production Management / Industrial Engineering useful

### Learning Outcomes

The students

- Know planning guidelines
- Know vulnerability analysis
- Are able to plan work systems (e.g. technical or organisational structuring principles, capacity planning, precedence diagram, wages system . . .)
- Are able to evaluate a planning solution
- Are able to present results

### Content

1. Planning guidelines
2. Vulnerability analysis
3. Planning of work systems (technical and organisational structuring principles, capacity planning, precedence diagram, wages system . . .)
4. Evaluation
5. Presentation

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- GROB, R.; HAFFNER, H.: Planungsleitlinien Arbeitsstrukturierung. Berlin, München:Siemens AG, 1982.

- GROB, R.: Erweiterte Wirtschaftlichkeits- und Nutzenrechnung. Köln: Verlag TÜV Rheinland, 1984.
- REFA - Verband für Arbeitsstudien und Betriebsorganisation (Hrsg.): Arbeitsgestaltung in der Produktion. München: Carl Hanser Verlag, 1991. (Methodenlehre der Betriebsorganisation)

**Course: Multi-scale Plasticity [2181750]****Coordinators:** K. Schulz, C. Greiner**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

presentation (40%), oral examination (30 min, 60%)

**Conditions**

- limited number of participants
- mandatory registration
- mandatory attendance

**Recommendations**

preliminary knowlegde in mathematics, physics, mechanics and materials science

**Learning Outcomes**

The student

- can explain the physical foundations of plasticity as well as results of latest research.
- can independently read and evaluate scientific research papers.
- can present specific, technical information in structured, precise, and readable manner.
- is able to argue for and/or against a particular approach or idea using the knowledge acquired within the lecture.

**Content**

This module will attempt to provide an overview to complex subjects in the field of material mechanics. For this purpose important scientific papers will be presented and discussed.

This will be done by having students read and critique one paper each week in a short review. In addition, each week will include presentation from one of the participants which aim to advocate or criticise each piece of work using the short reviews. He will also be the discussion leader, while students discuss the content, ideas, evaluation and open research questions of the paper. Using a professional conference management system (HotCRP), the student assume the role of reviewers and gain insight into the work of researchers.

**Media**

black board, beamer, script

**Remarks**

The maximum number of students is 14 per semester.

## Course: PLM for Product Development in Mechatronics [2122376]

**Coordinators:** M. Eigner

**Part of the modules:** SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

The assessment consists of an oral exam (30 min.).

### Conditions

None.

### Learning Outcomes

Students have a basic overview about product data management and product lifecycle management.

Students know components and core functions of PLM solutions

Students can describe trends in research and practice in the environment of PLM

### Content

*Product Data Management*

*Product Lifecycle Management*

**Course: PLM in the Manufacturing Industry [2121366]****Coordinators:** G. Meier**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral group examination, Duration 1 hour, Auxiliary Means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

Students know essential aspects of PLM Processes which are exemplarily introduced with examples from Heidelberger Druckmaschinen.

Students know objects of the PLM Process and know the interconnection between CAD and PLM.

Students understand the procedure of PLM-installation in an industrial enterprise and occurring challenges concerning strategy, vendor selection and psychology.

They are able to create installation concepts for PLM systems in the scope of team exercises and explain the approaches in presentations.

**Content**

A description of systematic requirement engineering is given, based on the introduction of PLM-Processes and (Multi-) Project management in the product development process. By the introduction of a PLM-Project, Objects of the PLM Process like material master, bill of material, documents and classifications are explained. Furthermore a 3D-Process chain is introduced to show the implementation of technical modifications. Finally, specific aspects of the mechatronic development are introduced.

**Literature**

Lecture slides

**Course: Polymer Engineering I [2173590]****Coordinators:** P. Elsner**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 36: Polymer Engineering (p. 454)[SP\_36\_mach], SP 47: Tribology (p. 466)[SP\_47\_mach], SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20-30 Minutes

**Conditions**

None.

**Learning Outcomes**

The field of Polymer Engineering includes synthesis, material science, processing, construction, design, tool engineering, production technology, surface engineering and recycling. The aim is, to equip the students with knowledge and technical skills, and to use the material "polymer" meeting its requirements in an economical and ecological way.

The students

- are able to describe and classify polymers based on the fundamental synthesis processing techniques
- can find practical applications for state-of-the-art polymers and manufacturing technologies
- are able to apply the processing techniques, the application of polymers and polymer composites regarding to the basic principles of material science
- can describe the special mechanical, chemical and electrical properties of polymers and correlate these properties to the chemical bindings.
- can define application areas and the limitation in the use of polymers

**Content**

1. Economical aspects of polymers
2. Introduction of mechanical, chemical and electrical properties
3. Processing of polymers (introduction)
4. Material science of polymers
5. Synthesis

**Literature**

Recommended literature and selected official lecture notes are provided in the lecture

**Course: Polymer Engineering II [2174596]****Coordinators:** P. Elsner**Part of the modules:** SP 36: Polymer Engineering (p. 454)[SP\_36\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20-30 Minutes

**Conditions**

Polymerengineering I

**Learning Outcomes**

The field of Polymer Engineering includes synthesis, material science, processing, construction, design, tool engineering, production technology, surface engineering and recycling. The aim is, that the students gather knowledge and technical skills to use the material “polymer” meeting its requirements in an economical and ecological way.

The students

- can describe and classify different processing techniques and can exemplify mould design principles based on technical parts.
- know about practical applications and processing of polymer parts
- are able to design polymer parts according to given restrictions
- can choose appropriate polymers based on the technical requirements
- can decide how to use polymers regarding the production, economical and ecological requirements

**Content**

1. Processing of polymers
  2. Properties of polymer components
- Based on practical examples and components
- 2.1 Selection of material
  - 2.2 Component design
  - 2.3 Tool engineering
  - 2.4 Production technology
  - 2.5 Surface engineering
  - 2.6 Sustainability, recycling

**Literature**

Recommended literature and selected official lecture notes are provided in the lecture

**Course: Polymers in MEMS A: Chemistry, Synthesis and Applications [2141853]****Coordinators:** B. Rapp**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The examination will be held in oral form at the end of the lecture. The lecture can be chosen as “Nebenfach” or part of a “Hauptfach”. The second lecture of the lecture series “Polymers in MEMS B – Physics, manufacturing and applications” (which is also held in winter semester) can be combined with this lecture as part of a “Hauptfach”. In summer semester, the third part of the lecture series “Polymers in MEMS C – Biopolymers, Biopolymers and applications” will be given which may be combined with lectures A and B to form a complete “Hauptfach”.

**Conditions**

Bachelor (or equivalent level) students with basic knowledge in material science and chemistry. The lecture will cover all the basics required for understanding the organic chemistry so detailed previous knowledge is not required. Basic understanding of MEMS and its technologies is helpful but not mandatory.

**Learning Outcomes**

The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge required for understanding what polymers are and how they are made, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.

After attending the lecture the students will be able:

- ... to understand the physico/chemical basics of organic chemistry in polymer synthesis.
- ... to state the most important polymers and polymer classes and to develop application examples for these.
- ... to state the most important polymers in MEMS.
- ... to understand the most important techniques for rapid prototyping.
- ... to state and to understand the most important resists in MEMS.
- ... to understand the chemical synthesis of polymers.

... to correctly estimate the application scope of the individual classes of polymers.

**Content**

We all come in contact with numerous polymeric products in everyday life. From water bottles to packaging to the cover of the iPad, many things are made of polymers. Polymers are also important materials for modern microelectromechanical systems (MEMS) allowing cost effective mass market compatible products, e.g., in the life sciences or diagnostics. But polymers are not just cost-effective replacements for more expensive classical materials in MEMS (such as, e.g., silicon) – some polymers have intrinsic properties that make them ideal materials for sensors, actuators or templates for biology and chemistry in MEMS.

This lecture will introduce the basics of organic chemistry required for understanding what polymers are, how they are manufactured and which mechanisms are responsible for their unique properties. The lecture will highlight (in the context of MEMS but also in a wider scope) where and why polymers are applied with a strong focus on their chemical and physical properties (and on their synthesis).

Some of the topics covered are:

- What is the basic chemistry of polymers? What are monomers, what are macromolecules and how are they formed?
- How are polymers produced on industrial scale – but also on the laboratory scale? Numerous examples of how to make (commonly and lesser known) polymers will be discussed including materials such as Plexiglas.
- Why are polymers so important for biochemistry and tissue engineering?
- How do photoresists work and why do some polymers contract when exposed to light?

- What are high-performance polymers and why do they have such a wide application range, e.g., in implants?
- What polymers fuel the household 3D printing community and what materials do 3D printers such as, e.g., the RepRap work with?
- How does 3D printing and rapid prototyping work and which polymers can be employed for which techniques?
- Why does silicone always smell like vinegar and why is this material so important for modern day microfluidics? How do you built fluid-logic devices using silicone?
- How do shape memory polymers remember their shape?
- What are polymer foams and why are they not only important for heat insulation but also for organic chemistry?
- How do glues work? Why are there two-component glues, what is superglue and how can you make glue from potatoes?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.

For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu). Preregistration is not necessary.

The examination will be held in oral form at the end of the lecture. The lecture can be chosen as “Nebenfach” or part of a “Hauptfach”. The second lecture of the lecture series “Polymers in MEMS B – Physics, manufacturing and applications” (which is also held in winter semester) can be combined with this lecture as part of a “Hauptfach”. In summer semester, the third part of the lecture series “Polymers in MEMS C – Biopolymers, Biopolymers and applications” will be given which may be combined with lectures A and B to form a complete “Hauptfach”.

#### **Media**

The lecture slides will be given out as scriptum during each lecture course.

#### **Remarks**

For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu). Preregistration is not necessary.

**Course: Polymers in MEMS B: Physics, Microstructuring and Applications [2141854]****Coordinators:** M. Worgull**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The examination will be held in oral form at the end of the lecture. The lecture can be chosen as “Nebenfach” or part of a “Hauptfach”. The second lecture of the lecture series „Polymers in MEMS A – Chemistry, synthesis and applications” (which is also held in winter semester) can be combined with this lecture as part of a “Hauptfach”. In summer semester, the third part of the lecture series “Polymers in MEMS C – Biopolymers, Biopolymers and applications” will be given which may be combined with lectures A and B to form a complete “Hauptfach”.

**Conditions**

Bachelor (or equivalent level) students with basic knowledge in material science and mechanical engineering. The lecture will cover all the basics required for understanding. Detailed knowledge of microsystem technology and its processes is helpful but not mandatory.

**Learning Outcomes**

The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge required for understanding what polymers are and how they are made, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.

After attending the lecture the students will be able:

- ... to understand the properties of polymers as a consequence of their morphology.
- ... to describe the most important structuring techniques and technologies for polymers in MEMS.
- ... to understand the mathematical basis of the most important physical models for polymers.
- ... to correctly judge polymer properties and the applicability of the polymers for their industrial processability.
- ... to understand the basics of process simulation in polymer structuring.
- ... to state the most important technical thermoplasts in MEMS and to understand their properties.
- ... to correctly classify the various types of polymers, blends, composite materials.

**Content**

We all come in contact with numerous polymeric products in everyday life. From water bottles to packaging to the cover of the iPad, many things are made of polymers. Polymers are also important materials for modern microelectromechanical systems (MEMS) allowing cost effective mass market compatible products, e.g., in the life sciences or diagnostics. But polymers are not just cost-effective replacements for more expensive classical materials in MEMS (such as, e.g., silicon) – some polymers have intrinsic properties that make them ideal materials for sensors, actuators or templates for biology and chemistry in MEMS.

This lecture will introduce the basics of physics and material science required for the understanding of the mechanical behavior seen from the engineers view. Micro and nanostructuring of polymers allows the fabrication of micro parts fulfilling their tasks in mostly invisible different applications. But also the fabrication of polymer parts with functional surfaces inspired from Bionics will be presented in this lesson. The lesson will give further an overview over the polymer based structuring processes and will underline the importance by a number of applications e.g. photonic structures or Lotus-like structures.

Some of the topics covered are:

- How can polymers described from the view of engineers?
- What are the differences between polymers and metals?
- Rheology of polymer melts – How does polymer melts flow?
- How can polymers be formed and demolded?

- Which structuring processes (replication) processes are available?
- How does stress influence molded parts (e.g. the deformation of a CD in a hot car)
- Shrinkage of polymers – which precision is achievable
- Gluing or welding – How can polymers be assembled?
- Simulation of replication processes
- Characterization of polymers – which properties can be measured?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.

For further details, please contact the lecturer, PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

The examination will be held in oral form at the end of the lecture. The lecture can be chosen as “Nebenfach” or part of a “Hauptfach”. The second lecture of the lecture series “Polymers in MEMS A – Chemistry, synthesis and applications” (which is also held in winter semester) can be combined with this lecture as part of a “Hauptfach”. In summer semester, the third part of the lecture series “Polymers in MEMS C – Biopolymers, Biopolymers and applications” will be given which may be combined with lectures A and B to form a complete “Hauptfach”.

#### **Media**

The lecture slides will be given out as scriptum during each lecture course.

#### **Remarks**

For further details, please contact the lecturer, PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

**Course: [2142855]****Coordinators:** M. Worgull, B. Rapp**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The examination will be held in oral form at the end of the lecture, duration 30 minutes. The lecture can be chosen as "Nebenfach" or part of a "Hauptfach". The lecture is the third in a row which complements the lectures „Polymer in MEMS A – Chemistry, synthesis and applications“ and "Polymers in MEMS B – Physics, manufacturing and applications". In that case there will be one examination with a duration of 60 minutes. These can be combined with this lecture as part of a "Hauptfach". In the summer semester, there will also be a block practical course "Polymers in MEMS".

**Conditions**

Students should also have attended either "Polymers in MEMS A" or "Polymers in MEMS B" during winter semester as this lecture will not provide a general introduction in the chemistry of polymers or polymer processing.

**Recommendations**

Bachelor (or equivalent level) students with basic knowledge in material science and chemistry. Basic understanding of MEMS and its technologies is helpful but not mandatory. Students should also have attended either "Polymers in MEMS A" or "Polymers in MEMS B" during winter semester as this lecture will not provide a general introduction in the chemistry of polymers or polymer processing.

**Learning Outcomes**

The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge of biopolymers and bioplastics, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.

After attending the lecture the students will be able:

- ... to correctly classify biopolymers and bioplastics.
- ... to correctly state their properties, advantages and disadvantages.
- ... to correctly estimate their application scope in MEMS.
- ... to understand their usage in everyday life.
- ... to correctly judge their sustainability.
- ... to develop further applications of this class of materials.

... to correctly estimate the suitability of biopolymers and bioplastics, especially compared to conventionally polymers.

**Content**

Polymers are ubiquitous in everyday life: from packaging materials all the way to specialty products in medicine and medical engineering. Today it is difficult to find a product which does not (at least in parts) consist of polymeric materials. The question of how these materials can be improved with respect to their disposal and consumption of (natural) resources during manufacturing is often raised. Today polymers must be fully recycled in Germany and many other countries due to the fact that they do not (or only very slowly) decompose in nature. Furthermore significant reductions of crude oil consumption during synthesis are of increasing importance in order to improve the sustainability of this class of materials. With respect to disposal polymers which do not have to be disposed by combustion but rather allow natural decomposition (composting) are of increasing interest. Polymers from renewable sources are also of interest for modern microelectromechanical systems (MEMS) especially if the systems designed are intended as single-use products.

This lecture will introduce the most important classes of these so-called biopolymers and bioplastics. It will also discuss and highlight polymers which are created from naturally created analogues (e.g. via fermentation) to petrochemical polymer precursors and describe their technical processing. Numerous examples from MEMS as well as everyday life will be given.

Some of the topics covered are:

- What are biopolyurethanes and how can you produce them from castor oil?
- What are “natural glues” and how are they different from chemical glues?
- How do you make tires from natural rubbers?
- What are the two most important polymers for life on earth?
- How can you make polymers from potatoes?
- Can wood be formed by injection molding?
- How do you make buttons from milk?
- Can you play music on biopolymers?
- Where and how do you use polymers for tissue engineering?
- How can you built LEGO with DNA?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.

For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu) and PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

**Literature**

Additional literature is not required.

**Remarks**

For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu) and PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

**Course: [2142856]****Coordinators:** M. Worgull, B. Rapp**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The practical course will close with an oral examination. There will be only passed and failed results, no grades.

**Conditions**

Having attended either "Polymers in MEMS A" or "Polymers in MEMS B" is a prerequisite for this practical course. For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu) and PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is mandatory. The number of participants is limited to 5 students.

**Recommendations**

Bachelor (or equivalent level) students with basic knowledge in material science and chemistry. Students must have attended either "Polymers in MEMS A" or "Polymers in MEMS B" during winter semester.

**Learning Outcomes**

The practical course will provide mechanical or chemical engineers, as well as interested students from the life or material sciences a deeper understanding of polymers, their synthesis and their processing.

After attending the lecture the students will be able:

- ... to synthesize relevant polymers on a laboratory scale.
- ... to characterize these materials.
- ... to structure these polymers.

... to use these polymers in exemplary MEMS applications..

**Content**

This practical course complements the lectures "Polymers in MEMS A", "Polymers in MEMS B" and "Polymers in MEMS C" and will allow students to gain a deeper understanding of polymers and their processing. During the course of this practical course, various polymers will be synthesized and molded into components suitable for microelectromechanical systems (MEMS) applications. The aim of the course is to bring a polymer all the way from synthesis to application.

The practical course will be given in German language unless non-German speaking students attend. In this case, the course will be given in English (with some German translations of technical vocabulary). Lecture notes for the experiments are in English language and will be handed out to the students. The practical course will be held "en block" at the end of the semester (presumably beginning of October)

For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu) and PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is mandatory. The number of participants is limited to 5 students.

**Media**

descriptions of the experiments

**Literature**

Scripts of the corresponding lectures, further literature as named there.

**Course: Laboratory “Laser Materials Processing” [2183640]****Coordinators:** J. Schneider, W. Pflöging**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 3              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

The assessment consists of an colloquium for every single experiment and an overall final colloquium incl. an oral presentation of 20 min.

**Conditions**

Basic knowledge of physics, chemistry and material science is assumed.

**Recommendations**

The attendance to one of the courses Physical Basics of Laser Technology (2181612) or Laser Application in Automotive Engineering (2182642) is strongly recommended.

**Learning Outcomes**

The student

- can describe the influence of laser, material and process parameters and can choose suitable parameters for the most important methods of laser-based processing in automotive engineering.
- can explain the requirements for safe handling of laser radiation and for the design of safe laser systems.

**Content**

The laboratory comprises 8 half-day experiments, which address the following laser processing topics of metals, ceramics and polymers:

- safety aspects
- surface hardening and remelting
- melt and reactive cutting
- surface modification by dispersing or alloying
- welding
- surface texturing
- metrology

There are used CO<sub>2</sub>-, excimer-, Nd:YAG- and high power diode-laser sources within the laboratory.

**Media**

lecture notes via ILIAS

**Literature**

W.T. Silfvast: Laser Fundamentals, 2008, Cambridge University Press  
W.M. Steen: Laser Materials Processing, 2010, Springer

**Remarks**

The maximum number of students is 12 per semester.

**Course: Lab Computer-aided methods for measurement and control [2137306]****Coordinators:** C. Stiller, P. Lenz**Part of the modules:** SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Winter term | de                   |

**Learning Control / Examinations**

Colloquia

**Conditions**

Basic studies and preliminary examination; basic lectures in automatic control

**Learning Outcomes**

Powerful and cheap computation resources have led to major changes in the domain of measurement and control. Engineers in various fields are nowadays confronted with the application of computer-aided methods. This lab tries to give an insight into the modern domain of measurement and control by means of practically oriented and flexible experiments. Based on experiments on measurement instrumentation and digital signal processing, elementary knowledge in the domain of visual inspection and image processing will be taught. Thereby, commonly used software like MATLAB/Simulink will be used in both simulation and realization of control loops. The lab closes with selected applications, like control of a robot or supersonic computer tomography.

**Content**

1. Digital technology
  2. Digital storage oscilloscope and digital spectrum analyzer
  3. Supersonic computer tomography
  4. Lighting and image acquisition
  5. Digital image processing
  6. Image interpretation
  7. Control synthesis and simulation
  8. Robot: Sensors
  - 9 Robot: Actuating elements and path planning
- The lab comprises 9 experiments.

**Literature**

Instructions to the experiments are available on the institute's website

**Course: Practical Course Technical Ceramics [2125751]****Coordinators:** R. Oberacker**Part of the modules:** SP 43: Technical Ceramics and Powder Materials (p. 462)[SP\_43\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Colloquium and laboratory report for the respective experiments.

**Conditions**

Laboratory report

**Recommendations**

Courses in ceramic materials

**Learning Outcomes**

The students are able to understand and to apply a number of basic laboratory methods used in processing and characterization of ceramic materials. They are qualified to apply new methods on the basis of standards and descriptions of experiments.

**Content**

Based on alumina as a model material, major test methods for the characterization of raw materials, intermediate and final products are practically applied. Topics:

- 
- powder characterization
- Shaping of powder compacts
- sintering
- microstructural characterization
- mechanical testing

On the basis of short descriptions of the methods, the students prepare themselves, carry out the experiments and write a laboratory report.

**Literature**

Salmang, H.: Keramik, 7. Aufl., Springer Berlin Heidelberg, 2007. - Online-Ressource

Richerson, D. R.: Modern Ceramic Engineering, CRC Taylor &amp; Francis, 2006

**Course: Introduction to Microsystem Technology - Practical Course [2143875]****Coordinators:** A. Last**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

non-graded: preparation of the experiments

graded (together with the lecture MST I resp. II): 50% questions concerning the practical training in the written 2h-exam of the lecture 'Grundlagen der Mikrosystemtechnik I resp. II'

**Conditions**

pre-condition: attendance of the lecture 'Grundlagen der Mikrosystemtechnik I bzw. II'

**Learning Outcomes**

- Deepening of the contents of the lecture MST I resp. II
- Understanding the technological processes in the micro system technology
- Experience in lab-work at real workplaces where normally research is carried out

**Content**

In the practical training includes nine experiments:

1. Hot embossing of plastics micro structures
2. Micro electroforming
3. Mikro optics: „LIGA-micro spectrometer“
4. UV-lithography
5. Optical waveguides
6. Capillary electrophoresis on a chip
7. SAW gas sensor
8. Metrology
9. Atomic force microscopy

Each student takes part in only five experiments.

The experiments are carried out at real workstations at the IMT and coached by IMT-staff.

**Course: Product Lifecycle Management [2121350]****Coordinators:** J. Ovtcharova**Part of the modules:** SP 37: Production Management (p. 455)[SP\_37\_mach], SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations**

written examination

Duration:

1,5 hours

Auxiliary Means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students can:

- clarify the management concept of PLM, its objectives and highlight the economic benefits of the PLM concept.
- illustrate the need for an integrated and cross-departmental business process - from planning, portfolio construction and return of customer information, from the use phase to maintenance and recycling of products.
- reason the processes and functions needed to support the entire product life cycle and discuss the main operating software systems (PDM, ERP, SCM, CRM) and their functions for supporting PLM.
- argue a method to successfully introduce the concept of Management PLM in companys.

**Content**

Product Lifecycle Management (PLM) is an approach to the holistic and cross-company management and control of all product-related processes and data throughout the life cycle along the extended supply chain - from design and production to sales, to the dismantling and recycling.

Product Lifecycle Management is a comprehensive approach for effective and efficient design of the product life cycle. Based on all product information, which comes up across the entire value chain and across multiple partners, processes, methods and tools are made available to provide the right information at the right time, quality and the right place.

The course covers:

- A consistent description of all business processes that occur during the product life cycle (development, production, sales, dismantling, ...)
- the presentation of methods for the performance of the PLM business processes,
- explaining the most important corporate information systems to support the life cycle (PDM, ERP, SCM, CRM systems) to sample the software manufacturer SAP

**Literature**

Lecture slides.

V. Arnold et al: Product Lifecycle Management beherrschen, Springer-Verlag, Heidelberg, 2005.

J. Stark: Product Lifecycle Management, 21st Century Paradigm for Product Realisation, Springer-Verlag, London, 2006.

A. W. Scheer et al: Prozessorientiertes Product Lifecycle Management, Springer-Verlag, Berlin, 2006.

J. Schöttner: Produktdatenmanagement in der Fertigungsindustrie, Hanser-Verlag, München, 1999.

M.Eigner, R. Stelzer: Produktdaten Management-Systeme, Springer-Verlag, Berlin, 2001.

G. Hartmann: Product Lifecycle Management with SAP, Galileo press, 2007.

K. Obermann: CAD/CAM/PLM-Handbuch, 2004.

**Course: Product, Process and Resource Integration in the Automotive Industry [2123364]****Coordinators:** S. Mbang**Part of the modules:** SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination, Durations: 20 min, Auxiliary Means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

A considerable aspect of this lecture is to combine engineering knowledge with the practical, real industrial problems and applications.

Thus, the objectives of the lecture are:

- collaborative drafting of industrial and academic state of the art regarding the basics.
- specification of exigencies, requirements and concepts for an integrated CAx-process chain,
- introduction in the paradigms of the integrated process-oriented product development
- to convey practical industrial knowledge about the integrated product development in the automotive sector

**Content**

The lecture

- Overview of product development in the automotive sector (process- and work cycle, IT-Systems)
- Integrated product models in the automotive industry (product, process and resource)
- New CAx modeling methods (intelligent feature technology, templates & functional modeling)
- Automation and knowledge-based mechanism for product design and production planning
- Product development in accordance with defined process and requirement (3D-master principle, tolerance models)
- Concurrent Engineering, shared working
- Enhanced concepts: the digital and virtual factory (application of virtual technologies and methods in the product development)
- Systems: CAD/CAM modeling (CATIA V5), planning (CATIA/DELMIA), archiving – PDM (CATIA/SmarTeam).

Additionally, A practical industrial project study is offered, which is based on an integrated application scenario (from design of production resources, over testing and validation method planning to the manufacturing and implementation of the production resources).

Since the student will be divided in small teams, this study will also teach the students about team work and distributed development.

**Literature**

Lecture slides

**Remarks**

Max. 20 students, registration necessary (ILIAS)

**Course: Production Management I [2109028]****Coordinators:** P. Stock**Part of the modules:** SP 37: Production Management (p. 455)[SP\_37\_mach], SP 16: Industrial Engineering (p. 429)[SP\_16\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations****Compulsory Core Subject:** oral exam**Elective Subject:** oral exam (ca. 30 min)**Optional Subject:** oral exam (ca. 30 min)

The exams are only offered in German!

**Conditions**

None.

**Recommendations**

- Willingness to learn interdisciplinarily (Technique, Economy, Legal regulations, Informatics ...)

**Learning Outcomes**

After completion this lecture, the students are able

- to describe the goals of production and production management,
- to describe the prevailing requirements of the working world and the thereof resulting fields of application of Production Management and to give examples,
- to describe and to apply basic theories, methods and tools for the different fields of application of Production Management on a strategical, tactical and operational level,
- to plan and control the industrial process of production and adding value,
- to evaluate the applied methods and tools of production management within a specific enterprise and to drive alternatives for organising and configuration a production system.

**Content**

1. Introduction
2. Strategy of enterprises
3. Product development and programme planning
4. Location planning
5. Enterprise system (Production system, fabric planning, departmental and process organisation)
6. Management of resources (personnel, machines, material)
7. Operations planning and control
8. Controlling
9. Management systems

**Literature**

Handout and literature online ILIAS.

**Course: Production Management II [2110028]****Coordinators:** P. Stock**Part of the modules:** SP 37: Production Management (p. 455)[SP\_37\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations****Elective Subject:** oral exam (ca. 30 min)**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

**Conditions**

None.

**Recommendations**

- Willingness to learn interdisciplinarily (Technique, Economy, Legal regulations, Informatics . . .)
- Knowledge of the lecture "Production Management I" (2109028) is compulsory

**Learning Outcomes**

After completion this lecture, the students are able

- to describe the actual trends of production management and their influence upon an enterprise,
- to identify interfaces to adjacent disciplines (e.g. business economics, computer science, political economics),
- to describe and to apply specific theories, methods and tools of Production Management (e.g. Kanban, Heijunka, Total Quality Management)
- to evaluate production systems and the applied methods, to identify problems in a production system and to organise and configure a production system,
- to evaluate the applied methods and tools of production management within a specific enterprise and to drive alternatives for organising and configuration a production system.

**Content**

The lecture presents selected methods of Production Management.

**Literature**

Handout and literature online ILIAS.

## Course: Production Planning and Control [2110032]

**Coordinators:** A. Rinn

**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 37: Production Management (p. 455)[SP\_37\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

### Conditions

- Compact course
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

### Recommendations

- Knowledge in Production Management (resp. Industrial Engineering) is necessary
- Knowledge of Work Science and Economics is usefull
- Knowledge of Informatics is not required, but usefull

### Learning Outcomes

- Get deeper insights within production management
- Increase knowledge of production planning and control
- Understand basic techniques for the modelling and simulation of production systems

### Content

1. Goals and recomanditions for production planning and control
2. Strategies for work control
3. Case study: Manufacturing of bicycles
4. FASI-Plus: Simulation of a bicycle factory for the production planning and control
5. Simulation of the order processing
6. Decision making about order control and procurement of purchased parts
7. Evaluation of the simulation protocols
8. Realisation of production planning and control

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- KOŠTURIAK, Ján; GREGOR, Milan: Simulation von Produktionssystemen. Wien, New York: Springer, 1995.
- LIEBL, Franz: Simulation. München, Wien: Oldenbourg, 2. Auflage 1995.
- VDI 3633, Blatt 6: Simulation von Logistik-, Materialfluss- und Produktionssystemen – Abbildung des Personals in Simulationsmodellen. Berlin: Beuth-Verlag, 2001.
- VDI 4499, Blatt 1: Digitale Fabrik - Grundlagen. Berlin: Beuth-Verlag, 2008.

Please refer to the latest edition.

## Course: Production Techniques Laboratory [2110678]

**Coordinators:** K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL  
**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 37: Production Management (p. 455)[SP\_37\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

### Learning Control / Examinations

**Advanced Internship:** Participate in practice exercise courses and complete the colloquia successfully.

**Elective Subject:** Participate in practice exercise courses and complete the colloquia successfully and presentation of a specific topic.

**Optional Subject:** Participate in practice exercise courses and complete the colloquia successfully and presentation of a specific topic.

### Conditions

None.

### Recommendations

Participation in the following lectures:

- Informationssysteme in logistics and supply chain management
- Material flow in logistic systems
- Manufacturing technology
- Human Factors Engineering

### Learning Outcomes

*The students acquire in the lab profound knowledge about the scientific theories, principles and methods of Production Engineering. Afterwards they are able to evaluate and design complex production systems according to problems of manufacturing and process technologies, materials handling, handling techniques, information engineering as well as production organisation and management.*

*After completion this lab, the students are able*

- *to analyse and solve planning and layout problems of the discussed fields,*
- *to evaluate and configure the quality and efficiency of production, processes and products,*
- *to plan, control and evaluate the production of a production enterprise,*
- *to configure and evaluate the IT architecture of a production enterprise,*
- *to design and evaluate appropriate techniques for conveying, handling and picking within a production system,*
- *to design and evaluate the part production and assembly respective to processes and work places.*

### Content

The production technique laboratory (PTL) is a collaboration of the institutes wbk, IFL, IMI and ifab.

1. Computer Aided Product Development (IMI)
2. Computer communication in factory (IMI)
3. Production of parts with CNC turning machines (wbk)
4. Controlling of production systems using PLCs (wbk)
5. Automated assembly systems (wbk)
6. Optical identification in production and logistics (IFL)

7. RFID identification systems (IFL)
8. Storage and order-picking systems (IFL)
9. Configuration of Display Work Stations (ifab)
10. Time study (ifab)
11. Workplace configuration (ifab)

**Media**

several

**Literature**

Handout and literature online ILIAS.

**Remarks**

none

**Course: Production Technology and Management in Automotive [2149001]****Coordinators:** V. Stauch, S. Peters**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The assessment is carried out as a written exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The students . . .

- are capable to specify the current challenges in automotive industry and to explain approaches to solve them.
- are able to classify the main parts of an automotive plant and its key elements (production facilities).
- are qualified to identify interlinkages between development processes and production systems (such as lean production).
- have the ability to classify modern concepts of logistics and tasks in management and design of value added networks.
- are enabled to explain the importance of an integrated quality management in product development and production as well as related methods.
- are able to characterize methodical approaches of analytical assessment and optimization of production planning tasks.

**Content**

The lecture deals with the technical and organizational aspects of automotive production. The course starts with an introduction to the automotive industry, current trends in vehicle technology and integrated product development. A selection of manufacturing processes are subjects of the second lecture block. Experiences of the applications of the Mercedes Production System in production, logistics and maintenance are the subject of the third event. During the last block approaches to quality management, global networks and current analytical planning methods in research are discussed. The course is strongly oriented towards the practice and is provided with many current examples. Mr. Stauch was Head of Powertrain Production Mercedes Benz Cars and plant manager Untertürkheim until 2010.

The following topics will be covered:

- Introduction to Automotive Industry and Technology
- Basics of Product Development
- Selected Automotive Manufacturing Technologies
- Automotive Production Systems
- Logistics
- Quality Assurance
- Global Networks
- Analytical Approaches of Production Planning

**Media**

Lecture slides will be provided printed.

**Literature**

Lecture Slides

**Remarks**

None

## Course: Productivity Management in Production Systems [2110046]

**Coordinators:** S. Stowasser

**Part of the modules:** SP 37: Production Management (p. 455)[SP\_37\_mach], SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

**Elective Subject:** oral exam (ca. 30 min)

**Optional Subject:** oral exam (ca. 30 min)

The exam is offered in German only!

### Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

### Recommendations

- Knowledge of work science is usefull

### Learning Outcomes

- Ability to design work operations and processes effectivly and efficiently
- Instruction in methods of time study (MTM, Data acquisition etc.)
- Instruction in methods and principles of process design
- The Students are able to apply methods for the design of workplaces, work operations and processes.
- The Students are able to apply actual approaches of process and production organisation.

### Content

1. Definition and terminology of process design and industrial engineering
2. Tasks of industrial engineering
3. Actual approaches of organisation of production (Holistic production systems, Guided group work et al.)
4. Methods and principles of industrial engineering and production systems
5. Case studies and exercises for process design

### Media

Powerpoint, movies, exercises

### Literature

#### Learning material:

Handout and literature online ILIAS.

#### Literature:

- BASZENSKI, Norbert: Methodensammlung zur Unternehmensprozessoptimierung. Köln: Wirtschaftsverlag Bachem, 3. Auflage 2008.
- BOKRANZ, Rainer; LANDAU, Kurt: Produktivitätsmanagement von Arbeitssystemen. Stuttgart: Schäffer Poeschel, 2006.
- Themenheft: Methodisches Produktivitätsmanagement: Umsetzung und Perspektiven. In: Zeitschrift angewandte Arbeitswissenschaft, Köln, 204(2010).
- NEUHAUS, Ralf: Produktionssysteme: Aufbau - Umsetzung - betriebliche Lösungen. Köln: Wirtschaftsverlag Bachem, 2008.
- ROTHER, Mike; SHOOK, John: Sehen lernen - mit Wertstromdesign die Wertschöpfung erhöhen und Verschwendung beseitigen. Aachen: Lean Management Institut, 2004.

Please refer to the latest edition.

**Course: Project Workshop: Automotive Engineering [2115817]****Coordinators:** F. Gauterin**Part of the modules:** SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 6            | 3              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

**Conditions**

None.

**Learning Outcomes**

The students are familiar with typical industrial development processes and working style. They are able to apply knowledge gained at the university to a practical task. They are able to analyze and to judge complex relations. They are ready to work self-dependently, to apply different development methods and to work on approaches to solve a problem, to develop practice-oriented products or processes.

**Content**

During the Project Workshop Automotive Engineering a team of six persons will work on a task given by an German industrial partner using the instruments of project management. The task is relevant for the actual business and the results are intended to be industrialized after the completion of the project workshop.

The team will generate approaches in its own responsibility and will develop solutions for practical application. Coaching will be supplied by both, company and institute.

At the beginning in a start-up meeting goals and structure of the project will be specified. During the project workshop there will be weekly team meetings. Also a milestone meeting will be held together with persons from the industrial company. In a final presentation the project results will be presented to the company management and to institute representatives.

**Literature**

Steinle, Claus; Bruch, Heike; Lawa, Dieter (Hrsg.), Projektmanagement, Instrument moderner Innovation, FAZ Verlag, Frankfurt a. M., 2001, ISBN 978-3929368277

The scripts will be supplied in the start-up meeting.

## Course: Project Mikro Manufacturing: Design and Manufacturing of Micro Systems [2149680]

**Coordinators:** V. Schulze, P. Hoppen

**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | de                   |

### Learning Control / Examinations

The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None

### Recommendations

Knowledge of CAD tools is favorable but not necessary. Previous knowledge of manufacturing is reasonable.

### Learning Outcomes

The students . . .

- are able to describe the micro manufacturing processes as well as their characteristics and applications.
- can choose suitable manufacturing processes for a given product.
- are able to describe the process along the CAD-CAM process chain from scratch to manufacturing.
- can explain how the development process for a micro product looks like.
- are able to describe how design for manufacturability works for micro products and where the differences to macroscopic scale are.

### Content

The course „Project micro manufacturing: design and manufacturing of a micro system“ combines the basics of micro manufacturing with project work. The project work will be done in cooperation with an industry partner. The students learn the basics of micro milling, micro electric discharge machining, micro laser ablation, micro powder injection molding and micro quality assurance. Furthermore they get to know the CAD-CAM process chain. That is the manufacturing of a production out of a CAD model. The students develop ideas and concepts matching the given task and present the results to the industry partner. Then they create parts that are designed for manufacturability out of their concepts. Those parts are manufactured at the wbk and finally assembled to a prototype. In winter semester 2012/13 innovative couplings for model railways were developed and functional prototypes were built.

### Media

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

### Literature

Lecture Notes

### Remarks

None

## Course: Development of Oil-Hydraulic Powertrain Systems [2113072]

**Coordinators:** G. Geerling, I. Ays

**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral examination

### Conditions

knowledge in the fluidics

### Learning Outcomes

The students are able to understand hydraulic systems and to develop them independently. They apply their competences in a simulation of a development project with real hydraulic components within a laboratory tutorial.

### Content

The bloc course offered by the Chair of Mobile Machines (Mobima) conveys the basics of planning and development of mobile and industrial hydrostatic systems. The lecturer works for a market leading company producing fluid power drives and controls and gives a deep view into the process of planning and development using real life examples. The contents of the course are:

- marketing, project planning
- hydrostatic circuits
- heat balance, hydraulic accumulators
- filtration, noise lowering
- development exercises + laboratory tutorial

**Course: Project Management in Rail Industry [2115995]****Coordinators:** P. Gratzfeld**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The students learn the basic of project management.

They learn about the roles of project manager and project core team.

They understand the project phases and know about processes and tools.

They understand the governance process behind.

**Content**

Rail vehicles are capital-intensive goods which are manufactured in small series (like aircraft). The work to done at industry and customers is organized in "projects". This is completely different to the way of working in large-scale production (like car industry). Everybody working in this type of business is part of a project and should be aware of the typical processes.

The lecturer provides a comprehensive overview about modern project management for small series of capital-intensive goods.

The content is not only valid for rail vehicles but also other areas.

The following topics will be discussed:

Introduction: definition of project and project management

Project management system: project phases, main processes and supporting processes, governance

Organization: organizational structure within a company, project organization, roles in a project organization

Main processes: project start, project plan, work brake down structure, detailed project schedule, risk and opportunity management, change management, project closure

Governance

**Media**

All slides are available for download (Ilias-platform).

**Literature**

A bibliography is available for download (Ilias-platform).

**Remarks**

None.

**Course: Project management in Global Product Engineering Structures [2145182]****Coordinators:** P. Gutzmer**Part of the modules:** SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 20: Integrated Product Development (p. 432)[SP\_20\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 37: Production Management (p. 455)[SP\_37\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach], (p. 475)[SP\_58\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 minutes

Auxiliary means: none

**Conditions**

none

**Learning Outcomes**

Project management is essential for successful companies.

The students are able to describe, explain and compare characteristics and attributes of product development processes based on practical examples of industry.

They are able to specify processes of product development, their necessary organization structures and important attributes.

The participants learn to identify and evaluate aspects of product management within international operating companies.

**Content**

Product development process

Coordination of product development and handling of complexity

project management

matrix organization

planning / specification / target system

interaction of development and production

**Literature**

lecture notes

**Course: Process Simulation in Forming Operations [2161501]****Coordinators:** D. Helm**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term |                      |

**Learning Control / Examinations**

oral examination (30 min)

**Conditions**

None.

**Learning Outcomes**

The students can

- describe and classify the most important forming methods
- explain the reasons for the die Ursachen für die gute Umformbarkeit von Metallen in Bezug zu den stattfindenden Phänomenen in der Mikrostruktur erläutern und den Bezug zu den Abläufen in den unterschiedlichen Fertigungsverfahren herstellen
- describe the kinematics of infinitesimal and finite deformations
- explain the differences between different stress tensors in case of finite deformations
- apply simple material models of elasticity and plasticity and explain their operation
- derive the equation of the finite element method based on the balance laws
- describe why the material models are necessary and how they are applied in the whole algorithm
- sketch the process of a FEM-simulation and give the relation to the theoretical basis

**Content**

Based on basics of continuum mechanics, material theory and numerics the lecture gives an introduction into the simulation of forming operations for metals

- plasticity for metallic materials: dislocations, twinning, phase transformations, anisotropy, hardening
- classification of forming operations and discussion of selected topics
- basics of tensor algebra and tensor analysis
- continuum mechanics: kinematics, finite deformations, balance laws, thermodynamics
- material theory: basics, modelling concepts, plasticity and visco plasticity, yield functions (von Mises, Hill, ...), kinematic and isotropic hardening, damage
- thermomechanical coupling
- modelling of contact
- finite element method: explicit and implicate formulations, types of elements, numerical integration of material models
- process simulation of selected problems of sheet metal forming

**Course: Advanced powder metals [2126749]****Coordinators:** R. Oberacker**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 43: Technical Ceramics and Powder Materials (p. 462)[SP\_43\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (20-30 min) taking place at the agreed date. The re-examination is offered upon agreement.

**Conditions**

None.

**Recommendations**

Knowledge of basic material science is assumed.

**Learning Outcomes**

The students know the basics of powder metallurgy. They are able to assess the conditions for applying either powder metallurgy or competing production methods. They have knowledge on production, properties and application of the most important PM materials.

**Content**

The lecture gives an overview on production, properties and application structural and functional powder metallurgy material. The following groups of materials are presented: PM High Speed Steels, Cemented Carbides, PM Metal Matrix Composites, PM Specialties, PM Soft Magnetic and Hard Magnetic Materials.

**Literature**

- W. Schatt ; K.-P. Wieters ; B. Kieback. „Pulvermetallurgie: Technologien und Werkstoffe“, Springer, 2007
- R.M. German. “Powder metallurgy and particulate materials processing. Metal Powder Industries Federation, 2005
- F. Thümmeler, R. Oberacker. “Introduction to Powder Metallurgy”, Institute of Materials, 1993

**Course: Quality Management [2149667]****Coordinators:** G. Lanza**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 20: Integrated Product Development (p. 432)[SP\_20\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 37: Production Management (p. 455)[SP\_37\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The assessment is carried out as a written exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The students . . .

- are capable to comment on the content covered by the lecture.
- are capable of substantially quality philosophies.
- are able to apply the QM tools and methods they have learned about in the lecture to new problems from the context of the lecture.
- are able to analyze and evaluate the suitability of the methods, procedures and techniques they have learned about in the lecture for a specific problem.

**Content**

Based on the quality philosophies Total Quality Management (TQM) and Six Sigma, the lecture deals with the requirements of modern quality management. Within this context, the process concept of a modern enterprise and the process-specific fields of application of quality assurance methods are presented. The lecture covers the current state of the art in preventive and non-preventive quality management methods in addition to manufacturing metrology, statistical methods and service-related quality management. The content is completed with the presentation of certification possibilities and legal quality aspects.

Main topics of the lecture:

- The term "quality"
- Total Quality Management (TQM) and Six Sigma
- Universal methods and tools
- QM during early product stages – product definition
- QM during product development and in procurement
- QM in production – manufacturing metrology
- QM in production – statistical methods
- QM in service
- Quality management systems
- Legal aspects of QM

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

**Course: Nuclear Fuel Cycle and Radiochemistry [5010]****Coordinators:** H. Geckeis**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term |                      |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content**

**Course: Reactor Safety I: Fundamentals [2189465]****Coordinators:** V. Sánchez-Espinoza**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

- Knowledge of fundamentals of nuclear safety (technology, atomic law, principles)
- Gain understanding of safety features and systems of a nuclear power plant
- Ability to understand the interactions of different areas e.g. thermal hydraulics, neutronics, materials, human factors, organisation and management of a nuclear power plant

**Content**

The goal of the lecture is to impart the fundamentals of nuclear safety that is needed to assess the safety of nuclear facilities. Nuclear safety is inherently of multidisciplinary character and is based on the following pillars: technology, man, organisation and measures; all together named "Safety Culture". The nuclear facilities, coal-fired power plants, aerospace industry and gen technology for example are connected with a certain risk for the environment and society. Consequently, the erection and operation of nuclear installations needs must undergo a licensing process and a continuous surveillance by the regulatory body. This lecture will be concentrated on the following topics:

- Historical development of nuclear safety
- Risk evaluation for nuclear power plants compared to other technologies
- Scope, principles and structure of the atomic Law (national and international context)
- Fundamentals of nuclear safety
- Safety features and systems of nuclear power plants with Light Water Reactors (Generation 2)
- Safety analysis and methods for safety assessment
- Validation of numerical simulation tools for safety demonstration
- Introduction to probabilistic safety assessment (PSA)
- Nuclear events and accidents
- Safety concepts of reactors of generation 3 and 4

**Literature**

Lecture notes

**Course: Computational Dynamics [2162246]****Coordinators:** C. Proppe**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

**Learning Control / Examinations**

Oral examination, no auxiliary means allowed

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The lecture teaches the ability to compute solutions for problems in structure dynamics. For this purpose differential equations for the vibration of structure elements are presented and solved by means of numerical methods.

**Content**

1. Fundamentals of elasto-kinetics (Equations of motion, principle of Hamilton and principle of Hellinger-Reissner)
2. Differential equations for the vibration of structure elements (bars, plates)
3. Numerical solutions of the equations of motion
4. Numerical algorithms
5. Stability analyses

**Literature**

1. Lecture notes (in German) will be provided!
2. M. Géradin, B. Rixen: Mechanical Vibrations, Wiley, Chichester, 1997

**Remarks**

The course takes place every two years (in pair years).

**Course: Computational Vehicle Dynamics [2162256]****Coordinators:** C. Proppe**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 50: Rail System Technology (p. 469)[SP\_50\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination, no auxiliary means allowed

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

This course serves as an introduction to the computational modelling and simulation of the technical system road/vehicle. A method based perspective is taken, which allows for a unified treatment of various kinds of vehicles. The vehicle model is obtained by dividing the system into functional subsystems and defining interfaces between these subsystems. In the first part of the course, vehicle models will be developed based on models of the suspensions, the road, and the contact forces between road and vehicle. The focus of the second part of the course is on computational methods for linear and non-linear models of vehicle systems. The third part of the course discusses design criteria for stability, safety and ride comfort. The multi body dynamics software Simpack will be used.

**Content**

1. Introduction
2. Models of load bearing systems
3. Contact forces between wheels and roadway
4. Simulation of roadways
5. Vehicle models
6. Methods of calculation
7. Performance indicators

**Literature**

1. K. Popp, W. Schiehlen: Fahrzeugdynamik, B. G. Teubner, Stuttgart, 1993
2. H.-P. Willumeit: Modelle und Modellierungsverfahren in der Fahrzeugdynamik, B. G. Teubner, Stuttgart, 1998
3. H. B. Pacejka: Tyre and Vehicle Dynamics. Butterworth Heinemann, Oxford, 2002
4. K. Knothe, S. Stichel: Schienenfahrzeugdynamik, Springer, Berlin, 2003

**Remarks**

The course takes place every two years (impair years only).

**Course: Computerized Multibody Dynamics [2162216]****Coordinators:** W. Seemann**Part of the modules:** SP 40: Robotics (p. 458)[SP\_40\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral exam

**Conditions**

Knowledge of EM III, EM IV

**Learning Outcomes**

Goal of the course is to demonstrate the students that many tasks which are necessary to derive the equations of motion can be done by computers and corresponding software. This enables the user to focus both on mechanics and on modelling. This includes both kinematics as well as dynamics and different methods to derive the equations of motion. The numerical integration is known and the students realize that the result of the simulation does not only depend on the physical model but also on the type of integration scheme and the corresponding parameters. Application of software without detailed knowledge of the principles which are behind this software is therefore dangerous.

**Content**

Description of the orientation of a rigid body, angular velocity, angular acceleration, derivatives in different reference frames, derivatives of vectors, holonomic and nonholonomic constraints, derivation of the equations of motion using d'Alembert's principle, the principle of virtual power, Lagrange's equations or Kane's equations. Structure of the equations of motion, foundations of numerical integration.

**Media**

Following Programs are used: AUTOLEV, MATLAB, MATHEMATICA/MAPLE

**Literature**

Kane, T.: Dynamics, Theory and Applications, McGrawHill, 1985  
 AUTOLEV: User Manual

**Course: Computer Integrated Planning of New Products [2122387]****Coordinators:** R. Kläger**Part of the modules:** SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination

Duration:

30 minutes

No tools or reference materials may be used during exam.

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students got a basic understanding of relations, procedures and structure elements of standard processes in product planning and are capable of using these as guidelines for planning of new products.

They acquired knowledge of requirements and options in choosing and applying the right methods and tools for an efficient and reasonable assistance for specific use cases.

The students are familiar with elements and methods of computer aided idea and innovation management. They acquired knowledge of simultaneous assistance to the product planning process by using the technologies of rapid prototyping during development phases.

**Content**

The increase in creativity and the strength of innovation for the planning and development of new products has become a key factor for the competitiveness of the industry. Shorter innovation cycles, an overwhelming flood of information and an increasing demand for information and communication makes the use of computer absolutely necessary. Against this background this lecture discusses the success factors for new products, and introduces a product innovation process in conjunction with planning of new products based on the concepts of system engineering. In the following the methodological assistance to this process is being discussed by introducing innovation management, idea management, problem solving strategies, creativity and rapid prototyping for instance.

**Literature**

Handouts during lecture

**Course: Computational Mechanics I [2161250]****Coordinators:** T. Böhlke, T. Langhoff**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

Prerequisites by attestations during associated tutorials

**Conditions**

None.

**Recommendations**

Lectures “Mathematical Methods in Strength of Materials” and “Introduction to the Finite Element Method”

This course is geared to MSc students.

**Learning Outcomes**

The students can

- analyse and evaluate different methods for solving linear systems of equations
- list and assess basics and assumptions of the linear elasticity
- list methods for solving the boundary value problem of linear elasticity
- apply and evaluate the matrix displacement method
- list and analyse variational principles of linear elasticity
- analyse the different aspects and steps of the finite-element-method
- solve worksheet problems to topics of the lecture by writing own MATLAB code

**Content**

- numerical solution of linear systems
- basics of boundary value problems of linear elasticity
- solution methods of boundary value problem of linear elasticity;
- matrix displacement method
- variational principles of linear elasticity
- finite-element-technology for linear static problems

**Literature**

Simó, J.C.; Hughes, T.J.R.: Computational Inelasticity. Springer 1998.

Haupt, P.: Continuum Mechanics and Theory of Materials. Springer 2002.

Belytschko, T.; Liu, W.K.; Moran, B.: Nonlinear FE for Continua and Structures. JWS 2000.

W. S. Slaughter: The linearized theory of elasticity. Birkhäuser, 2002.

J. Betten: Finite Elemente für Ingenieure 2, Springer, 2004.

**Course: Computational Mechanics II [2162296]****Coordinators:** T. Böhlke, T. Langhoff**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Summer term | de                   |

**Learning Control / Examinations**

oral examination

**Conditions**

Successful participation in lecture "Computational Mechanics I"

**Recommendations**

This course is geared to MSc students.

**Learning Outcomes**

The students can

- apply and evaluate algorithms for solving a non-linear equation of systems of equations
- compute stresses and strains in the framework of linear elasticity and of infinitesimal plasticity
- apply and assess models of generalized standard materials
- list the basic equations of linear thermo-elasticity
- develop user-subroutines within FORTRAN for use within commercial FE-Codes
- perform a finite-element-analysis with ABAQUS for elastic-plastic materials using or developing user-subroutines

**Content**

- overview quasistatic nonlinear phenomena
- numerics of nonlinear systems
- foundations of nonlinear continuum mechanics
- balance equations of geometrically nonlinear solid mechanics
- finite elasticity
- infinitesimal plasticity
- linear and geometrically nonlinear thermoelasticity

**Literature**

Simó, J.C.; Hughes, T.J.R.: Computational Inelasticity. Springer 1998. Haupt, P.: Continuum Mechanics and Theory of Materials. Springer 2002. Belytschko, T.; Liu, W.K.; Moran, B.: Nonlinear FE for Continua and Structures. JWS 2000.

## Course: Reduction methods for the modeling and the simulation of combustion processes [2166543]

**Coordinators:** V. Bykov, U. Maas

**Part of the modules:** SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach],  
SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

Oral

Duration: 30 min.

### Conditions

None

### Recommendations

None

### Learning Outcomes

After completing this course students can:

- 
- explain the fundamental mathematical concepts in model reduction for reacting flows.
- perform an analysis of kinetic models of reacting flows.
- analyse ideal and reduced models used to describe different combustion regimes
- understand and assess the predominant methods for the mathematical analysis of reduced models.

### Content

Fundamentals of the mathematical methods and the analysis of chemical kinetics

Methodology of model reduction and its implementation

Description of different combustion regimes (e.g. auto-ignition, steady flames, flame quenching) with simplified and idealised models

Examples of reduction strategies

### Literature

Course notes

N. Peters, B. Rogg: Reduced kinetic mechanisms for application in combustion systems, Lecture notes in physics, 15, Springer Verlag, 1993

**Course: Robotics I – Introduction to robotics [24152]****Coordinators:** R. Dillmann, S. Schmidt-Rohr**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The assessment is explained in the module description.

**Conditions**

None.

**Recommendations**

It is recommended to attend "Cognitive Systems" prior to this lecture. It is further recommended to attend "Robotik II" and „Robotik III" in conjunction with „Robotik I".

**Learning Outcomes**

This lecture gives an overview of basic methods and components for building and running a robotic platform. The lecture aims at the communication of methodical understanding regarding the organization of robot system architectures.

**Content**

The lecture gives an overview of the research field of robotics. Robotic systems in industrial manufacturing as well as service robots are covered. The key aspects consist in modelling of robots as well as methods for robot control.

First, the different system and control components of a robotic platform are discussed. Methods for robot modelling such as kinematics and dynamics modelling are covered. Based on these models, approaches for control, planning and collision avoidance are discussed. Finally, robot architectures are introduced which comprise the previously studied approaches and models.

**Media**

Slides

**Literature****Elective literature:**

Fu, Gonzalez, Lee: Robotics - Control, Sensing, Vision, and Intelligence  
 Russel, Norvig: Artificial Intelligenz - A Modern Approach, 2nd. Ed.

**Course: Robotics II - Learning and planning robots [24712]****Coordinators:** R. Dillmann**Part of the modules:** SP 40: Robotics (p. 458)[SP\_40\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment is explained in the module description.

**Conditions**

None.

**Recommendations**

Previous attendance of the lecture „Robotics I” is helpful, but not mandatory.

**Learning Outcomes**

The student understands the main principles and differences concerning methods for programming industrial robots on the one hand and autonomous service robots on the other hand. The student is able to present and describe applicable programming concepts for realistic robotic application scenarios

**Content**

Complementary to the lectures „Robotik I” and „Robotik III”, the programming and task modeling aspects of robotics are presented more closely. Different methods like manual, textual and graphic programming of robots as well as the necessary tools are discussed. Furthermore, the internal modeling of environment and task knowledge in the robot as well as suitable planning methods are presented. Finally, decision making and planning approaches for autonomous service robots are discussed with a focus on dynamic, real world settings and the latest state of the art.

**Media**

Slides, script, work sheets

**Course: Robotik III - Sensors in Robotics [24635]****Coordinators:** R. Dillmann, Meißner, Gonzalez, Aguirre**Part of the modules:** SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment is explained in the module description.

**Conditions**

None.

**Recommendations**

Previous attendance of the lecture „Robotik I“ is helpful, but not mandatory.

**Learning Outcomes**

The student has to understand the principles of sensors that are essential and common in robotics. The student has to understand the data flow, starting from the physical measurement, over digitization, application of the sensor model to image processing, feature extraction and the integration of the information in an environment model. The student has to be able to propose suitable sensor concepts for simple tasks and to justify them.

**Content**

The lecture Robotics III complements the lecture Robotics I with a broad overview over sensors used in robotics and the interpretation of their data. One focus of the lecture is on the topic of computer vision, which is being dealt with from data acquisition, over calibration to object recognition and localization.

Sensors are important subcomponents of control circuits and enable robots to perform their tasks safely. Furthermore sensors serve to capture the environment as well as dynamical processes and actions in the surroundings of the robots. The topics that are addressed in the lecture, are as follows: Sensor technology for a whole taxonomy of sensor systems (including image and 3D sensors), sensor modeling (including color calibration and hdr imaging), theory and practice of digital signal processing, machine vision, multi-sensor integration and fusion.

Among others, sensor systems such as relative position sensors (optical encoders, potentiometer), velocity sensors (encoder, tachometer), acceleration sensors (piezo-resistive, piezo-electric, optical and others), inertial sensors (gyroscope, gravitometer and others), tactile sensors (foil sensors, pressure sensitive materials and others), proximity sensors, distance sensors (ultrasonic, laser, time-of-flight, interferometry, structured light, stereo camera systems and others), image sensors (photodiode, CCD and others), absolute position sensors (GPS, fiducial markers). Laser sensors as well as image sensors are dealt with priority.

**Media**

Slides, script.

**Course: Medical Robotics [24681]****Coordinators:** J. Raczkowsky, Raczkowsky**Part of the modules:** SP 32: Medical Technology (p. 448)[SP\_32\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment is explained in the module description.

**Conditions**

None.

**Learning Outcomes**

The student should understand the specific demands of surgical treatments on automation using robot. Additionally he/she should become acquainted with basic methods of registration of image data and how to use them. This includes also also physical registration. Generally, the course should enable the student to design a work flow for a robot assisted treatment.

**Content**

In the motivation, various scenarios of robot assisted usage in surgical environment will be described and by examples categorized. The basics of robotics will be entertained by the classic kinematic configurations. The characteristic indicators like degree of freedom, kinematic chain, work space and work load will be introduced. Then, the different modules of the robot assisted surgical work flow will be figured out. This starts with the description of all relevant tomographical modalities. They will be explicated by their physical basics and their measurement evidence for anatomical and pathological information. Data formats and communication play an important role in this context. This will be followed by medical image processing with the focus on segmentation. The next step is the geometrical 3D reconstruction of anatomical structures. This leads to an attributed patient model using the processed data of different tomographical modalities. This will be completed by different approaches for the modelling of tissue parameters. The usage of the attributed patient model for reasons of visualisation and operation planning is the next issue. The differing concepts of planning by medical doctors and engineers will be shown in this frame. Beside geometrical planning the role of work flow planning will be worked out. This becomes a more and more important topic in clinical routine. Simulation could be seen as a verification instrument of operation planning. Sub topics in this context is functional anatomical simulation, robot simulation with positioning verification and training systems. The intraoperative part of the robot aided work flow comprises physical registration, navigation, augmented reality and surgical robot systems. They will exemplified by basic principles and examples of applications. Important topics in this frame are techniques of tissue cutting and approaches for micro and nano surgery. The lecture closes with a short discourse on specific safety matters and legal aspects of medical products.

**Media**

PowerPoint-slides online

**Literature****Elective literature:**

- Springer Handbook of Robotics, Siciliano, Bruno; Khatib, Oussama (Eds.) 2008, LX, 1611 p. 1375 illus., 422 in color. With DVD., Hardcover, ISBN:978-3-540-23957-4
- Heinz Wörn, Uwe Brinkschulte "Echtzeitsysteme", Springer, 2005, ISBN: 3-540-20588-8
- Proceedings of Medical image computing and computer-assisted intervention (MICCAI ab 2005)
- Proceedings of Computer assisted radiology and surgery (CARS ab 2005)
- Tagungsbände Bildverarbeitung für die Medizin (BVM ab 2005)

**Course: Decommissioning of Nuclear Facilities I [19435]****Coordinators:** S. Gentes**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The examination results from the chosen module, otherwise:

Oral examination

**Conditions**

none

**Learning Outcomes**

Understanding Germany's authorization/licensing process, designing decommissioning concepts, basics and application of technologies and processes required for the decommissioning of nuclear facilities as well as the legal framework required for decommissioning processes

**Content**

State of the science and technical knowledge of mechanical process engineering for decommissioning (e.g. decontamination, separation of steel and reinforced concrete, demolition of highly reinforced concrete, management of the entire decommissioning process, etc.) as well as modern management methods required for the complex handling of decommissioning projects.

In addition, basic knowledge of the approval chain and the legal framework will be taught. To see the work put into practice a nuclear facility currently under decommissioning will be visited.

**Literature**

NomosGesetze: „Atomgesetz mit Verordnungen“, ISBN: 978-3-8329-2833-9

atw – International Journal of Nuclear Power, ISSN: 1431-5254

**Course: Rail Vehicle Technology [2115996]****Coordinators:** P. Gratzfeld**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 minutes

No tools or reference materials may be used during the exam.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

The students learn about advantages and disadvantages of different types of traction drives and judge which one fits best for each application.

They understand brakes from a vehicular and an operational point of view. They assess the fitness of different brake systems.

They know about the basics of running dynamics and bogies.

They define suitable vehicle concepts based on requirements for modern rail vehicles.

**Content**

Vehicle system technology: structure and main systems of rail vehicles

Drives: Electric and non-electric traction drives

Brakes: Tasks, basics, principles, brake control

Bogies: forces, running gears, axle configuration

Vehicle concepts: trams, metros, regional trains, double deck coaches, locomotives

Examples of existing rail vehicles were discussed.

**Media**

All slides are available for download (Ilias-platform).

**Literature**

A bibliography is available for download (Ilias-platform).

**Remarks**

None.

**Course: Welding Technology I [2173565]****Coordinators:** B. Spies**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes  
(Welding Technology I+II)

no auxiliary material

**Conditions**

basics of material science ( iron- and non-iron alloys), of electrical engineering, of production processes.

**Learning Outcomes**

The students have knowledge and understanding of the most important welding processes and its industrial application.

They are able to recognize, understand and handle problems occurring during the application of different welding processes relating to design, material and production.

They know the classification and the importance of welding technology within the scope of connecting processes (advantages/disadvantages, alternatives).

**Content**definition, application and differentiation: welding,  
welding processes,  
alternative connecting technologies.  
history of welding technology  
sources of energy for welding processesSurvey: fusion welding,  
pressure welding.  
seam preparation/design  
welding positions  
weldability  
gas welding, thermal cuttingmanual metal-arc welding  
submerged arc welding  
IV characteristics: arc/sources of energy  
gas-shielded metal-arc welding**Literature**Handbuch der Schweißtechnik I bis III  
Werkstoffe  
Verfahren und Fertigung  
Konstruktive Gestaltung der Bauteile  
Jürgen Ruge  
Springer-Verlag GmbH & Co, Berlin

Schweißtechnische Fertigungsverfahren 1 bis 3

Schweiß- und Schneidtechnologien  
Verhalten der Werkstoffe beim Schweißen  
Gestaltung und Festigkeit von Schweißkonstruktionen  
Ulrich Dilthey (1-3), Annette Brandenburger(3)  
Springer-Verlag GmbH & Co, Berlin

Fachbuchreihe Schweißtechnik Band 76/I und II  
Killing, R.; Böhme, D.; Hermann, F.-H.  
DVS-Verlag

DIN/DVS -TASCHENBÜCHER  
Schweißtechnik 1,2 ff...  
Beuth-Verlag GmbH, Berlin

**Course: Welding Technology II [2174570]****Coordinators:** B. Spies**Part of the modules:** SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 1              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes (Welding Technology I + II)

no auxiliary material

**Conditions**

lecture on Welding Technology I.

basics of material science (iron- and non-iron alloys), of electrical engineering, of production processes.

**Learning Outcomes**

The students can recognize, understand and handle the problems occurring during the application of different welding processes relating to design, material and production.

They obtain consolidation of and amplification to the knowledge of Welding Technology I.

Furthermore they have knowledge of material behaviour during welding, of design and properties of welded constructions as well as of quality assurance for welding processes.

**Content**

narrow gap welding

TIG-welding

plasma arc welding

electron beam welding

laser welding

spot welding / projection welding

heat flow at welding

welding of low-alloy steel / time-temperature-transformation curve.

welding of high-alloy steel / austenite / Schaefflerdiagramm

low temperature steels

welding of cast iron

heat treatment for welding

welding of aluminium alloys

residual welding stress

methods of testing

design of welded constructions

**Literature**

Handbuch der Schweißtechnik I bis III

Werkstoffe

Verfahren und Fertigung

Konstruktive Gestaltung der Bauteile

Jürgen Ruge

Springer-Verlag GmbH &amp; Co, Berlin

Schweißtechnische Fertigungsverfahren 1 bis 3  
Schweiß- und Schneidtechnologien  
Verhalten der Werkstoffe beim Schweißen  
Gestaltung und Festigkeit von Schweißkonstruktionen  
Ulrich Dilthey (1-3), Annette Brandenburger(3)  
Springer-Verlag GmbH & Co, Berlin

Fachbuchreihe Schweißtechnik Band 76/I und II  
Killing, R.; Böhme, D.; Hermann, F.-H.  
DVS-Verlag

DIN/DVS -TASCHENBÜCHER  
Schweißtechnik 1,2 ff...  
Beuth-Verlag GmbH, Berlin

**Course: Fatigue of Metallic Materials [2173585]****Coordinators:** K. Lang**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: 30 minutes

none

**Conditions**

none, basic knowledge in Material Science will be helpful

**Learning Outcomes**

The students are able to recognise the deformation and the failure behaviour of metallic materials under cyclic loading and to assign it to the basic microstructural processes. They know the sequence and the development of fatigue damages and can evaluate the initiation and the growth of fatigue cracks.

The students can assess the cyclic strength behaviour of metallic materials and components both qualitatively and quantitatively and know the procedures for the assessment of single-stage, multistage and stochastic cyclical loadings. Furthermore, they can take into account the influence of residual stresses.

**Content**

Introduction: some interesting cases of damage

Cyclic Stress Strain Behaviour

Crack Initiation

Crack Propagation

Lifetime Behaviour under Cyclic Loading

Fatigue of Notched Components

Influence of Residual Stresses

Structural Durability

**Literature**

Lecture notes that include a list of current literature will be distributed.

**Course: Schwingungstechnisches Praktikum [2161241]****Coordinators:** H. Hetzler, A. Fidlin**Part of the modules:** SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Colloquium to each session.

**Conditions**

None.

**Recommendations**

Vibration theory, mathematical methods of vibration theory, dynamic stability, nonlinear vibrations

**Learning Outcomes**

- \* Introduction to common measurement principles for mechanical vibrations
- \* selected vibrational problems are demonstrated from a theoretical and experimental aspect
- \* Measurement, evaluation and comparison with analytical calculations.

**Content**

- \* Frequency response of a force-excited oscillator (1DoF)
- \* stochastically excited oscillator (1DoF)
- \* digital processing of measurement data
- \* forces vibrations of a Duffing oscillator
- \* isolation of acoustical waves by means of additional masses
- \* critical speeds of a rotor in elastic bearings
- \* stability of a parametrically excited oscillator
- \* experimental modal analysis
- \* friction induced vibrations

**Literature**

comprehensive instructions will be handed out

**Course: [5012053]****Coordinators:** T. Meyer**Part of the modules:** SP 12: Automotive Technology (p. [426](#))[SP\_12\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

oral (thesis paper and presentation)

**Conditions**

None.

**Learning Outcomes**

The students acquired basic knowledge and an overview about automobile and traffic history with changing focus every semester.

**Content**

Seminar focus changes every semester, details see public announcement.

**Literature**

Seminar focus changes every semester, details see public announcement.

**Course: Safety Engineering [2117061]****Coordinators:** H. Kany**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach], SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach], SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral / written (if necessary) =&gt; (see "Studienplan Maschinenbau", version of 29.06.2011)

examination aids: none

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Students are able to:

- Name and describe relevant safety concepts of safety engineering,
- Discuss basics of health at work and labour protection in Germany,
- Evaluate the basics for the safe methods of design of machinery with the national and european safety regulations and
- Realize these objectives by using examples in the field of storage and material handling systems.

**Content**

The course provides basic knowledge of safety engineering. In particular the basics of health at the working place, job safety in Germany, national and European safety rules and the basics of safe machine design are covered. The implementation of these aspects will be illustrated by examples of material handling and storage technology. This course focuses on: basics of safety at work, safety regulations, basic safety principles of machine design, protection devices, system security with risk analysis, electronics in safety engineering, safety engineering for storage and material handling technique, electrical dangers and ergonomics. So, mainly, the technical measures of risk reduction in specific technical circumstances are covered.

**Media**

presentations

**Literature**

Defren/Wickert: Sicherheit für den Maschinen- und Anlagenbau, Druckerei und Verlag: H. von Ameln, Ratingen, ISBN: 3-926069-06-6

**Remarks**

none

**Course: Signals and Systems [23109]****Coordinators:** F. Puente, F. Puente León**Part of the modules:** SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The assessment consists of a written exam (approx. 120 minutes) according to sec. 4 subsec. 2 no. 1 study and examination regulations.

The grade of the course corresponds to the grade of the written exam.

**Conditions**

Knowledge of higher mathematics and probability theory (1305) is required.

**Learning Outcomes****Content****Media**

Slides

work sheets

**Literature**

Prof. Dr.-Ing. Kiencke: Signale und Systeme; Oldenbourg Verlag, 2008

**Elective literature:**

Will be announced in the lecture.

## Course: Simulation of Coupled Systems [2114095]

**Coordinators:** M. Geimer

**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 4              | Summer term | de                   |

### Learning Control / Examinations

The assessment consists of an oral exam (20 min) taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

### Conditions

It is recommended to have:

- Knowledge of ProE (ideally in current version)
- Basic knowledge of Matlab/Simulink
- Basic knowledge of dynamics of machines
- Basic knowledge of hydraulics

### Learning Outcomes

After completion of the course, students are able to:

- building a coupled simulation
- parameterize models
- Perform simulations
- do Troubleshooting
- check results for plausibility

### Content

- Knowledge of the basics of multi-body and hydraulic simulation programs
- Possibilities of coupled simulations
- Development of a simulation model by using the example of a wheel loader
- Documentation of the result in a short report

### Literature

#### Elective literature:

- miscellaneous guides according the software-tools pdf-shaped
- information to the wheel-type loader

**Course: Simulation in product development process [2185264]****Coordinators:** T. Böhlke**Part of the modules:** SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Not graded:

term paper in group work

- written part: 10 pages per person
- presentation: 15 minutes per group

**Conditions**

Compulsory preconditions: none

**Recommendations**

None.

**Learning Outcomes**

The students learn the connections between simulation methods, the necessary IT technique and the integration of such methods within the product development process. They know the basic approximation methods in mechanics and methods of modelling material behaviour using the finite-element-method. The students learn the integration within the product development process as well as the necessity of coupling different methods and systems. They master the modelling of heterogeneous technical systems and know the foundations of virtual reality.

**Content**

- approximation methods of mechanics: FDM, BEM, FEM, MBS
- material modelling using the finite-element-methode
- product life cycle
- coupling of methods and system integration
- modelling heterogeneous technical systems
- functional Digital Mock-Up (DMU), virtual prototypes

**Literature**

sildes of lectures will be available

## Course: Simulation of production systems and processes [2149605]

**Coordinators:** K. Furmans, V. Schulze, P. Stock

**Part of the modules:** SP 33: Microsystem Technology (p. 450)[SP\_33\_mach], SP 37: Production Management (p. 455)[SP\_37\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 4              | Winter term | de                   |

### Learning Control / Examinations

The assessment is carried out as a written exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

### Conditions

None.

### Recommendations

Regular attendance in the exercises.

### Learning Outcomes

The students . . .

- can explain the procedure of a simulation study and the respective steps.
- are able to explain the different modeling approaches that are available to describe production systems in matters of production technology, systems of work and material flow, to analyze and evaluate the results.
- are able to define the different modeling approaches for the description of machining processes and their advantages and disadvantages.
- are able to specify methods for simulation of plants and factories and classify them according to their capabilities.
- are able to define basics in statistics.
- are able to both calculate performance indicators of material flow systems and evaluate real systems according to these performance indicators.
- are able to use the basic tools of a discrete-event simulation software and can evaluate simulation results.
- are able to describe how real systems can be modeled as well as how models can be used and their results can be evaluated.
- are able to perform a personnel-oriented simulation study and can evaluate its results concerning different key figures.
- are able to apply common techniques for verification and simulation and can evaluate the validity of a simulation study with these techniques.

### Content

The aim of the lecture is to present the different aspects and possibilities of application of simulation technologies in the field of production systems and processes. Various simulation methods in the fields of production and manufacturing technology, work systems and the material flow for the production systems will be presented.

The following topics will be covered:

- Statistical basics (probability distribution and random numbers and their applications in the Monte Carlo simulation)
- Simulation of factories, machinery and processes (analysis of single manufacturing processes, machine tools and a digital plant)
- Simulation of work systems (personnel and oriented simulation of the digital plant)

- Design and validation of the simulations study (the procedure of a simulations study with the preparation work, the selection of the tools, the validation and the analysis/evaluation)

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

## Course: Simulation Aided Management [2109032]

**Coordinators:** P. Stock

**Part of the modules:** SP 37: Production Management (p. 455)[SP\_37\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 16: Industrial Engineering (p. 429)[SP\_16\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

### Learning Control / Examinations

Oral exam, length: 30 minutes  
(only in English)

Allowed resource materials: none

### Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration (First Come First Served)
- Registration via ILIAS necessary
- Compulsory attendance during the whole lecture

### Recommendations

- Knowledge in Production Management (resp. Industrial Engineering) is necessary
- Knowledge of Informatics is not required, but usefull

### Learning Outcomes

After completion this lecture, the students are able

- to describe the goals of production and production planning and control,
- to describe and to apply fundamental theories and methods of production planning and control (especially order planning, planning of demand and purchase, planning of resources, planning of lot sizes, Kanban),
- to describe and to apply fundamental methods for the configuration of assembly systems (especially group work, planning and balancing of an assembly line),
- to describe the approach of a simulation study, to identify needed input data for a simulation study for a specific example and to evaluate the results of a simulation study,
- to evaluate macro work systems within production, to identify occuring problems and to drive alternatives for organising and configuration for a specific work system.

### Content

Within the week-long compact seminar the participants are required to solve various production management scenarios in a group format. They will thereby have the opportunity to influence the solution process from various perspectives and to recognize the effects of individual actions on the entire relationship.

The seminar contains a planning game based on the re-arrangement of a production company and thereby gives the participants the chance to put the studied methods into practice. With the simulation, the solution is quantitatively assessed and the effects of decisions will be highlighted.

The structure of the lecture is:

1. Introductory lecture
2. Organisational issues

3. Planning scenario of a bicycle factory
4. Basics of operations planning and control (OPC)
5. Basics of operations structuring (OST)
6. Introduction of the simulation package
7. Instructions for OPC
8. Instructions for OST
9. Instructions for the final presentation
10. Final presentation

**Literature**

Handout and literature online ILIAS.

**Course: Simulator Exercises Combined Cycle Power Plants [2170491]****Coordinators:** T. Schulenberg**Part of the modules:** SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 2            | 2              | Summer term | en                   |

**Learning Control / Examinations**

Certificate of participation in case of regular attendance.

Oral examination on request.

**Conditions**

Participation at the lecture Combined Cycle Power Plants (2170490) is required.

**Learning Outcomes**

The simulator exercise offers the opportunity to run an advanced combined cycle power plant with a realistic user surface including all plant details at real time. Participant shall get a deeper understanding of the design of combined cycle power plants and their operation.

**Content**

Exemplary programming of an own I&C modul; start-up of the power plant from scratch; load changes and shut down; dynamic response of the power plant in case of malfunctions and of sudden load changes; manual operation of selected components.

The simulator exercise includes a tour to a combined cycle power plant at the end of the semester.

**Media**

The power plant simulator is based on the control system of a real SIEMENS power plant. The English user surface is based on US standard.

**Literature**

Slides and other documents of the lecture Combined Cycle Power Plants.

**Course: Scaling in fluid dynamics [2154044]****Coordinators:** L. Bühler**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 minutes

no auxiliary means

**Conditions**

none

**Learning Outcomes**

The student can extract non-dimensional number from the characteristic properties of flows. From the insights on scaling laws, the students are qualified to identify the influencing quantities from generic experiments and transfer these to real applications. The students can simplify the governing equations of fluid mechanic appropriately and can interpret the achieved results as a basis for efficient solution strategies.

**Content**

- Introduction
- Similarity rules (examples)
- Dimensional analysis (Pi-theorem)
- Scaling in differential equations
- Scaling in boundary layers
- Self-similar solutions
- Scaling in turbulent shear layers
- Rotating flows
- Magnetohydrodynamic flows

**Literature**

G. I. Barenblatt, 1979, Similarity, Self-Similarity, and Intermediate Asymptotics, Plenum Publishing Corporation (Consultants Bureau)

J. Zierep, 1982, Ähnlichkeitsgesetze und Modellregeln der Strömungsmechanik, Braun

G. I. Barenblatt, 1994, Scaling Phenomena in Fluid Mechanics, Cambridge University Press

**Course: Mechatronic Softwaretools [2161217]****Coordinators:** C. Proppe**Part of the modules:** SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 50: Rail System Technology (p. 469)[SP\_50\_mach], SP 06: Computational Mechanics (p. 419)[SP\_06\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

certificate of attendance (no grade), oral (colloquium)

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

After an introduction to the commercial software packages Maple, Matlab, Simulink, and Adams, students are able to select a suitable software package for a given mechatronic problem and to implement a model for solving the problem.

**Content**

1. Introduction to Maple: Generating of the nonlinear equations of motion for a double pendulum. Stability and resonance investigation of a Laval-rotor.
2. Introduction to Matlab: Dynamic simulation of a basic vehicle model using the Runge-Kutta-method. Solution of the partial differential equation for a rod by a Galerkin approximation.
3. Introduction to Simulink: Block diagrams of one-mass- and two-mass-oscillators. PID-distance control of two vehicles.
4. Introduction to Adams: Modelling and dynamic simulation of a simple robotic manipulator.

**Literature**

Hörhager, M.: Maple in Technik und Wissenschaft, Addison-Wesley-Longman, Bonn, 1996

Hoffmann, J.: Matlab und Simulink, Addison-Wesley-Longman, Bonn, 1998

Programmbeschreibungen des Rechenzentrums Karlsruhe zu Maple, Matlab und Simulink

**Course: Track Guided Transport Systems - Technical Design and Components [6234701]****Coordinators:** E. Hohnecker**Part of the modules:** SP 50: Rail System Technology (p. 469)[SP\_50\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes

No tools or reference materials may be used during the exam.

**Conditions**

See module description.

**Learning Outcomes**

See German Version.

**Content**

Law and Organisation of track guided transport systems, basics of driving dynamics, dimensioning and construction of railway tracks, basics of railway facilities, basics of signalling

**Literature**

Zilch, Diederichs, Katzenbach, Beckmann (Hrsg): Handbuch für Bauingenieure, Springer-Verlag 2012

**Course: Theory of Stability [2163113]****Coordinators:** A. Fidlin**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 30: Applied Mechanics (p. 445)[SP\_30\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 min (optional subject)

20 min (major subject)

Means are not allowed

**Conditions**

None.

**Recommendations**

Vibration theory, mathematical methods of vibration theory

**Learning Outcomes**

- to learn the most important methods of the stability analysis
- to apply the stability analysis for equilibria
- to apply the stability analysis for periodic solution
- to apply the stability analysis for systems with feedback control

**Content**

- Basic concepts of stability
- Lyapunov's functions
- Direct Lyapunov's methods
- Stability of equilibria positions
- Attraction area of a stable solution
- Stability according to the first order approximation
- Systems with parametric excitation
- Stability criteria in the control theory

**Literature**

- Pannovko Y.G., Gubanov I.I. Stability and Oscillations of Elastic Systems, Paradoxes, Fallacies and New Concepts. Consultants Bureau, 1965.
- Hagedorn P. Nichtlineare Schwingungen. Akademische Verlagsgesellschaft, 1978.
- Thomsen J.J. Vibration and Stability, Order and Chaos. McGraw-Hill, 1997.

**Course: Control Technology [2150683]****Coordinators:** C. Gönheimer**Part of the modules:** SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment is carried out as an oral exam. The examination is offered every semester twice. Reexaminations are offered at every ordinary examination date.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The students . . .

- are able to name the electrical controls which occur in the industrial environment and explain their function.
- can explain fundamental methods of signal processing. This involves in particular several coding methods, error protection methods and analog to digital conversion.
- are able to choose and to dimension control components, including sensors and actors, for an industrial application, particularly in the field of plant engineering and machine tools. Thereby, they can consider both, technical and economical issues.
- can describe the approach for projecting and writing software programs for a programmable logic control named Simatic S7 from Siemens. Thereby they can name several programming languages of the IEC 1131.

**Content**

The lecture control technology gives an integral overview of available control components within the field of industrial production systems. The first part of the lecture deals with the fundamentals of signal processing and with control peripherals in the form of sensors and actors which are used in production systems for the detection and manipulation of process states. The second part handles with the function of electric control systems in the production environment. The main focus in this chapter is laid on programmable logic controls, computerized numerical controls and robot controls. Finally the course ends with the topic of cross-linking and decentralization with the help of bus systems.

The lecture is very practice-oriented and illustrated with numerous examples from different branches.

The following topics will be covered

- Signal processing
- Control peripherals
- Programmable logic controls
- Numerical controls
- Controls for industrial robots
- Process control systems
- Field bus
- Trends in the area of control technology

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

**Course: Radiation Protection I: Ionising Radiation [23271]****Coordinators:** B. Breustedt, M. Urban**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 53: Fusion Technology (p. 471)[SP\_53\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (approx. 20 minutes) according to sec. 4 subsec. 2 no. 2 study and examination regulations.

**Conditions**

None.

**Learning Outcomes**

The Students know about the basics of radiation protection concerning ionizing radiation.

**Content**

The lecture shows the basics of radiation protection concerning ionizing radiation.

**Course: Strategic Product Planning [2146193]****Coordinators:** A. Siebe**Part of the modules:** SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 51: Development of innovative appliances and power tools (p. 470)[SP\_51\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 20: Integrated Product Development (p. 432)[SP\_20\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral exam

duration: 20 minutes

**Conditions**

none

**Learning Outcomes**

After listening to this lecture the students is able to ...

- describe the importance and goals of future management in product planning.
- to evaluate the different approaches of strategic product planning under consideration of the particular application.
- describe the approaches of a strategic szenario-based product planning.
- illustrate the strategic szenario-based product planning based on examples.

**Content**

Introduction into future management, Development of scenarios, szenariobased strategy development, trendmanagement, strategic early detection, innovation- and technologymanagement, szenarios in product development, from profiles of requirements to new products, examples out of industrial praxis.

**Course: Flows in rotating systems [2154407]****Coordinators:** R. Bohning**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes (optional subject), 20 minutes (major subject)

No tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

The students can describe the fundamental phenomena involved as well as the mathematical and physical aspects of rotating fluid flows, which occur in a wide variety of technical contexts and in geophysics, particularly in the atmosphere and in the oceans. They are qualified to transfer the obtained knowledge for characteristic flow problems of this field to practical examples.

**Content**

- Introduction
- Governing equations in a rotating System
- Exact solutions (circular flows)
- Dynamic similarity (Rossby Number Ekman Number)
- Hyperbolicity (Inertia waves, Rossby waves)
- Taylor Proudman theorem
- Ekman-layer
- Instabilities in rotating systems

**Literature**

Greenspan, H. P.: The Theory of Rotating Fluids

Lugt, H. J.: Wirbelströmungen in Natur und Technik, Braun Verlag, Karlsruhe, 1979

Lugt, H. J.: Vortex Flow in Rotating Fluids (with Mathematical Supplement), Wiley Interscience

Pedlovsky, J.: Geophysical Fluid Dynamic

**Course: Flows with chemical reactions [2153406]****Coordinators:** A. Class**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 min  
as WF NIE  
written homework

Lecture

**Conditions**

Mathematics

**Learning Outcomes**

The students can describe flow scenarios, where a chemical reaction is confined to a thin layer. They can choose simplifying approaches for the underlying chemistry and discuss the problems with focus on the fluid mechanic aspects. The students are able to solve simple problems analytically. Furthermore, they are qualified to discuss simplifications as relevant for an efficient numerical solution of complex problems.

**Content**

In the lecture we mainly consider problems, where chemical reaction is confined to a thin layer. The problems are solved analytically or they are at least simplified allowing for efficient numerical solution procedures. We apply simplified chemistry and focus on the fluid mechanic aspects of the problems.

**Media**

Black board

**Literature**

Lecture

Buckmaster, J.D.; Ludford, G.S.S.: Lectures on Mathematical Combustion, SIAM 1983

## Course: Flows and Heat Transfer in Energy Technology [2189910]

**Coordinators:** X. Cheng

**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral examination; duration: 20min

### Conditions

None.

### Learning Outcomes

This lecture is dedicated to students of mechanical engineering and other engineering Bachelor or Master degree courses. Goal of the lecture is the understanding of major processes in fluid dynamics and heat transfer in energy engineering. The corresponding phenomena and the methods to analyse are described and explained. In addition the lecture will be supplemented by convenient examples.

### Content

1. collection of sample applications
2. heat transfer and its application
3. convective fluid dynamics and heat transfer
4. thermal radiation and its application
5. special cases

### Literature

- Bahr, H.D., Stephan, K., Wärme- und Stoffübertragung, 3. Auflage Springer Verlag, 1998
- Mueller, U., Zweiphasenströmung, Vorlesungsmanuskript, Februar 2000, TH Karlsruhe
- Mueller, U., Freie Konvektion und Wärmeübertragung, Vorlesungsmanuskript, WS1993/1994, TH Karlsruhe
- W. Oldekop, „Einführung in die Kernreaktor und Kernkraftwerktechnik,“ Verlag Karl Thiemig, München, 1975
- Cacuci, D.G., Badea, A.F., Energiesysteme I, Vorlesungsmanuskript, 2006, TH Karlsruhe
- Jones, O.C., Nuclear Reactor Safety Heat Transfer, Hemisphere Verlag, 1981
- Herwig, H., Moschallski, A., Wärmeübertragung, 2. Auflage, Vieweg + Teubner, 2009

**Course: Flow Simulations with OpenFOAM [2154445]****Coordinators:** B. Frohnäpfel, C. Bruzzese**Part of the modules:** SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Homework and Colloquium

**Conditions**

None.

**Recommendations**

Fundamental Knowledge about Fluid Flows

**Learning Outcomes**

Students can simulate characteristic flow scenarios with the open source software OpenFOAM. They can apply this software application oriented. In this context, they are able to abstract the flow problem, generate the grid, define boundary and initial conditions and compute the flow field. They are able to choose the required models depending of the flow type, estimate the numerical effort, pre-process and run the simulation as well as evaluate and critically analyze the results.

**Content**

Flow Simulations with OpenFOAM

- grid generation, grid dependency of the solution
- initial and boundary conditions
- stationary and instationary flows
- interpretation of generated data
- turbulence modelling with RANS models
- comparison of laminar and turbulent flows
  - logarithmic wall law
  - heat and momentum transport
- understanding the structure of OpenFOAM and how to extend it for specific applications

**Literature**H. Ferziger, M. Peric, *Computational Methods for Fluid Dynamics*, Springer, 2008**Remarks**

Block course with limited number of participants, registration in the secretary's office required. See details at [www.istm.kit.edu](http://www.istm.kit.edu)

**Course: Structural and phase analysis [2125763]****Coordinators:** S. Wagner**Part of the modules:** SP 43: Technical Ceramics and Powder Materials (p. 462)[SP\_43\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

20 min

auxiliary means: none

**Conditions**

None.

**Learning Outcomes**

The students know the fundamentals of crystallography, the generation and detection of x-rays as well as their interaction with the microstructure of crystalline materials. They have detailed knowledge about the different methods of x-ray diffraction measurements and are able to analyze x-ray spectra using modern methods of x-ray analysis both qualitatively and quantitatively.

**Content**

The course gives an overview to generation and detection of x-rays as well as their interaction with matter. It provides an introduction to crystallography and describes modern measurement and analysis methods of x-ray diffraction.

It is arranged in the following units:

- 
- Generation and properties of X-Ray's Crystallography
- Fundamentals and application of different measuring methods
- Qualitative and quantitative phase analysis
- Texture analysis (pole figures)
- Residual stress measurements

**Literature**

- 1.
2. B.D. Cullity and S.R. Stock: Elements of X-ray diffraction. Prentice Hall New Jersey, 2001.

**Course: Structural Ceramics [2126775]****Coordinators:** M. Hoffmann**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 43: Technical Ceramics and Powder Materials (p. 462)[SP\_43\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (20 min) taking place at the agreed date.

Auxiliary means: none

The re-examination is offered upon agreement.

**Conditions**

none

**Recommendations**

Basics of the course "Introduction to Ceramics" should be known.

**Learning Outcomes**

The students know the most relevant structural ceramics (silicon carbide, silicon nitride, alumina, boron nitride, zirconia, fibre-reinforced ceramics) and their applications. They are familiar with the microstructural features, fabrication methods, and mechanical properties.

**Content**

The lecture gives an overview on structure and properties of the technical relevant structural ceramics silicon nitride, silicon carbide, alumina, zirconia, boron nitride and fibre-reinforced ceramics. All types of structural ceramics will be discussed in detail in terms of preparation methods of the raw materials, shaping techniques, densification, microstructural development, mechanical properties and application fields.

**Media**

Slides for the lecture:

available under <http://www.iam.kit.edu/km>

**Literature**

W.D. Kingery, H.K. Bowen, D.R. Uhlmann, "Introduction to Ceramics", John Wiley & Sons, New York, (1976)

E. Dörre, H. Hübner, "Alumina", Springer Verlag Berlin, (1984)

M. Barsoum, "Fundamentals of Ceramics", McGraw-Hill Series in Material Science and Engineering (2003)

**Remarks**

The course will not take place every year.

**Course: Superhard Thin Film Materials [2177618]****Coordinators:** S. Ulrich**Part of the modules:** SP 47: Tribology (p. 466)[SP\_47\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination (30 min)

no tools or reference materials

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

Superhard materials are solids with a hardness higher than 4000 HV 0,05. The main topics of this lecture are modelling, deposition, characterization and application of superhard thin film materials.

**Content**

Introduction

Basics

Plasma diagnostics

Particle flux analysis

Sputtering and ion implantation

Computer simulations

Properties of materials, thin film deposition technology, thin film analysis and modelling of superhard materials

Amorphous hydrogenated carbon

Diamond like carbon

Diamond

Cubic Boronnitride

Materials of the system metall-boron-carbon-nitrogen-silicon

**Literature**

G. Kienel (Ed.): Vakuumbeschichtung 1 - 5, VDI Verlag, Düsseldorf, 1994

Copies with figures and tables will be distributed

**Course: Supply chain management [2117062]****Coordinators:** K. Alicke**Part of the modules:** SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach], SP 29: Logistics and Material Flow Theory (p. 444)[SP\_29\_mach], SP 19: Information Technology of Logistic Systems (p. 431)[SP\_19\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 4              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

No tools or reference materials may be used during the exam.

**Conditions**

limited number: application necessary

**Recommendations**

none

**Learning Outcomes**

Students are able to:

- Discuss the requirements on modern supply chains,
- Use the basic concepts of demand forecast, stock optimization and supply in practical exercises,
- Analyse the typical questions of dimensioning a supply chain and evaluate a supply chain with the results.

**Content**

- Bullwhip-Effect, Demand Planning & Forecasting
- Conventional planning processes (MRP + MRP II)
- Stock keeping strategy
- Data acquisition and analysis
- Design for logistics (Postponement, Mass Customization, etc.)
- Logistic partnerships (VMI, etc.)
- Distribution structures (central vs. distributed, Hub&Spoke)
- SCM-metrics (performance measurement) e-business
- Special sectors as well as guest lectures

**Media**

presentations

**Literature**

Alicke, K.: Planung und Betrieb von Logistiknetzwerken

Simchi-Levi, D., Kaminsky, P.: Designing and Managing the Supply Chain

Goldratt, E., Cox, J.: The Goal

**Remarks**

this course is a block course

## Course: Sustainable Product Engineering [2146192]

**Coordinators:** K. Ziegahn

**Part of the modules:** SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 20: Integrated Product Development (p. 432)[SP\_20\_mach], SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], (p. 475)[SP\_58\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term |                      |

### Learning Control / Examinations

The type of examination (written or oral) will be announced at the beginning of the lecture.

written examination: 60 min duration

oral examination: 20 min duration

### Conditions

none

### Learning Outcomes

The goal of the lecture is to convey the main elements of sustainable product development in the economic, social and ecological context.

The students are able to ...

- identify und describe the sustainability objectives and their role in product development, the interaction between technical products and their environment, the holistic approach and the equality of economic, social and environmental aspects and environmental aspects.
- discuss the skills for life-cycle product design using the example of complex automotive components such as airbag systems and other current products.
- understand the product environmental stresses with relevancy to praxis at the example of technology-intensive components, robustness and durability of products as the basis for a sustainable product development, development of skills for the application of environmental simulation during the process of development of technical products.
- develop skills such as team skills / project / self / presentation based on realistic projects.

### Content

understanding of sustainability objectives and their role in product development, the interaction between technical products and their environment, the holistic approach and the equality of economic, social and environmental aspects and environmental aspects

skills for life-cycle product design using the example of complex automotive components such as airbag systems and other current products

understanding of product environmental stresses with relevancy to praxis at the example of technology-intensive components, robustness and durability of products as the basis for a sustainable product development, development of skills for the application of environmental simulation during the process of development of technical products

delivery of key skills such as team skills / project / self / presentation based on realistic projects

## Course: System Integration in Micro- and Nanotechnology [2106033]

**Coordinators:** U. Gengenbach

**Part of the modules:** SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 54: Microactuators and Microsensors (p. 472)[SP\_54\_mach], SP 32: Medical Technology (p. 448)[SP\_32\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

### Learning Control / Examinations

oral

### Conditions

None.

### Learning Outcomes

Students acquire fundamental knowledge about challenges and system integration processes.

### Content

- Introduction
- Definition system integration
- Integration of mechanical functions (flexures)
- Plasma treatment of surfaces
- Adhesive bonding
  - Packaging
  - Low Temperature Cofired Ceramics (LTCC)
  - Assembly of hybrid systems
- Monolithic/hybrid system integration)
- Modular system integration
- Integration of electrical/electronic functions
- Mounting techniques
- molded Interconnect Devices (MID)
- Functional printing
- Coating
- Capping
- Housing

First steps towards system integration nanotechnology

### Literature

- A. Risse, Fertigungsverfahren der Mechatronik, Feinwerk- und Präzisionsgerätetechnik, Vieweg+Teubner Verlag Wiesbaden, 2012
- M. Madou, Fundamentals of microfabrication and nanotechnology, CRC Press Boca raton, 2012
- G. Habenicht, Kleben Grundlagen, Technologien, Anwendungen, Springer-Verlag Berlin Heidelberg, 2009
- J. Franke, Räumliche elektronische Baugruppen (3D-MID), Carl Hanser-Verlag München, 2013

**Course: Technical Acoustics [2158107]****Coordinators:** M. Gabi**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], (p. 475)[SP\_58\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes

No tools or reference materials may be used during the exam.

**Conditions**

none

**Recommendations**

none

**Learning Outcomes**

Students get to know the basics of technical acoustics in general. Application of the knowledge in different fields of engineering.

Students learn physical basics of acoustics and human perception. Physical-empirical laws for determination of sound and noise levels of various emission and immission situations will be worked out or derived. Furtheron general sound measurement methods of machinery will be taught.

Students are able to understand mechanisms of sound origin, propagation and reduction, as well as measuring technics

**Content**

Basics of acoustics

Perception and weighting of noise (human hearing)

Description of acoustic parameters, level notation

Noise propagation

Acoustical measurement techniques

**Literature**

1. Lecture notes (downloadable from institute's homepage).
2. Heckl, M.; Müller, H. A.: Taschenbuch der Technischen Akustik, Springer-Verlag.
3. Veit, Ivar: Technische Akustik. Vogel-Verlag (Kamprath-Reihe), Würzburg.
4. Henn, H. et al.: Ingenieurakustik. Vieweg-Verlag.

**Course: [2157200]****Coordinators:** H. Henning**Part of the modules:** SP 55: Energy Technology for Buildings (p. 473)[SP\_55\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations****Conditions**

Can not be combined with the lecture Energy and indoor climate concepts for high performance buildings [1720997]

**Learning Outcomes****Content**

**Course: [2158201]****Coordinators:** H. Henning**Part of the modules:** SP 55: Energy Technology for Buildings (p. 473)[SP\_55\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations****Conditions**

Can not be combined with the lecture Energy and indoor climate concepts for high performance buildings [1720997]

**Learning Outcomes****Content**

**Course: Computer Engineering [2106002]****Coordinators:** G. Bretthauer**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Written examination

Duration: 2 hours (compulsory subject)

Auxiliary means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students possess essential knowledge about information processing in digital computers. Based on information representation and calculations of complexity, students are capable to design algorithms efficiently. The students are able to apply the knowledge about efficient algorithm design to important numerical computation methods in mechanical engineering. Students understand the importance of software quality in mechanical engineering and know basic concepts and important measures of quality assurance.

**Content**

Introduction: definitions, basic concepts, introductory examples

Information coding on finite automata: numbers, characters, commands, examples

Algorithm design: definitions, complexity of algorithms, complexity classes P and NP, examples

Sorting algorithms: relevance, algorithms, simplifications, examples

Software quality assurance: terms and measures, errors, phases of quality assurance, constructive measures, analytical measures, certification

Lectures are complemented by an exercise course.

**Literature**

Vorlesungsskript (Internet)

Becker, B., Molitor, P.: Technische Informatik : eine einführende Darstellung. München, Wien : Oldenbourg, 2008.

Hoffmann, D. W.: Grundlagen der Technischen Informatik. München: Hanser, 2007.

Balzert, H.: Lehrbuch Grundlagen der Informatik : Konzepte und Notationen in UML, Java und C++, Algorithmen und Software-Technik, Anwendungen. Heidelberg, Berlin : Spektrum, Akad. Verl., 1999.

Trauboth, H.: Software-Qualitätssicherung : konstruktive und analytische Maßnahmen. München, Wien : Oldenbourg, 1993.

**Course: Vibration Theory [2161212]****Coordinators:** A. Fidlin**Part of the modules:** SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 5            | 3              | Winter term | de                   |

**Learning Control / Examinations**

Written exam

If course is chosen as optional subject or part of major subject:

Oral exam, 30 minutes (optional subject), 20 minutes (major subject), no means

**Conditions**

None.

**Recommendations**

Examen in Engineering Mechanics 3 + 4

**Learning Outcomes**

The course gives an introduction into the vibration theory of linear systems. First, general vibration in form of harmonic signals is considered. One degree of freedom systems are treated in detail for free and forced vibration, especially for harmonic, periodic and arbitrary excitation. This is the foundation for systems with many degrees of freedom as these may be transformed with the help of modal coordinates. For multiple dof systems the eigenvalue problem is solved. Then forced vibration is treated. Finally, wave propagation problems and eigenvalue problems for systems with distributed parameters are discussed. As an application an introduction into rotor dynamics is given.

Goal of the course is to see the similarities for systems with one dof and with multiple dof. Besides typical phenomena like resonance a systematic mathematical approach to vibration problems and an interpretation of the mathematical results should be obtained.

**Content**

Concept of vibration, superposition of vibration with equal and with different frequencies, complex frequency response.

Vibration of systems with one dof: Free undamped and damped vibration, forced vibration for harmonic, periodic and arbitrary excitation. Excitation of undamped vibration in resonance.

Systems with many degrees of freedom: Eigenvalue problem for undamped vibration, orthogonality of eigenvectors, modal decoupling, approximation methods, eigenvalue problem for damped vibration. Forced vibration for harmonic excitation, modal decomposition for arbitrary forced vibration, vibration absorber.

Vibration of systems with distributed parameters: Partial differential equations as equations of motion, wave propagation, d'Alembert's solution, Ansatz for separation of time and space, eigenvalue problem, infinite number of eigenvalues and eigenfunctions.

Introduction to rotor dynamics: Laval rotor in rigid and elastic bearings, inner damping, Laval rotor in anisotropic bearings, synchronous and asynchronous whirl, rotors with asymmetric shaft.

**Literature**

Klotter: Technische Schwingungslehre, Bd. 1 Teil A, Heidelberg, 1978

Hagedorn, Otterbein: Technische Schwingungslehre, Bd 1 and Bd 2, Berlin, 1987

Wittenburg: Schwingungslehre, Springer-Verlag, Berlin, 1995

**Course: Technical Design in Product Development [2146179]****Coordinators:** M. Schmid**Part of the modules:** SP 03: Human Factors Engineering (p. 415)[SP\_03\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

For the reason of high student number the exam is a written exam.  
Only dictionary is allowed.

**Conditions**

Authorisation by the Examination Office.

**Recommendations**

None

**Learning Outcomes**

After listening the module „technical design“ the students should have knowledge about the basics of technical oriented design as an integral part of the methodical product development

The students have knowledge about ...

- the interface between engineer and designer.
- all relevant human-product requirements as f. exp. demographic/ geographic and psychographic features, relevant perceptions, typical content recognition as well as ergonomic bases.
- the approaches concerning the design of a product, product program or product system with focus on structure, form-, color- and graphic design within the phases of the design process.
- the design of functions and supporting structures as well as the important interface between human and machine.
- relevant parameters of a good corporate design.

**Content**

Introduction

Relevant parameters on product value in Technical Design

Design in Methodical Development and Engineering and for a differentiated validation of products

Design in the concept stage of Product Development

Design in the draft and elaboration stage of Product Development

**Literature**

Hexact (R) Lehr- und Lernportal

**Course: Technology of steel components [2174579]****Coordinators:** V. Schulze**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

duration 20 minutes

No tools or reference materials may be used during the exam

**Conditions**

Materials Science and Engineering I &amp; II

**Learning Outcomes**

The students have the background to evaluate the influence of manufacture processes on the compound state of metallic compounds. The students can assess the influence and the stability of compound state under mechanical load. The students are capable to describe the individual aspects of interaction of the compound state of steel components due to forming, heat treatment, mechanical surface treatment and joining processes.

**Content**

Meaning, Development and characterization of component states  
 Description of the influence of component state on mechanical properties  
 Stability of component states  
 Steel manufacturing  
 Component states due to forming  
 Component states due to heat treatments  
 Component states due to surface hardening  
 Component states due to machining  
 Component states due to mechanical surface treatments  
 Component states due to joining  
 Summarizing evaluation

**Literature**

Script will be distributed within the lecture

VDEh: Werkstoffkunde Stahl, Bd. 1: Grundlagen, Springer-Verlag, 1984

H.-J. Eckstein: Technologie der Wärmebehandlung von Stahl, Deutscher Verlag Grundstoffindustrie, 1977

H.K.D.H. Badeshia, R.W.K. Honeycombe, Steels - Microstructure and Properties, CIMA Publishing, 3. Auflage, 2006

V. Schulze: Modern Mechanical Surface Treatments, Wiley, Weinheim, 2005

**Course: Ten lectures on turbulence [2189904]****Coordinators:** I. Otic**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 53: Fusion Technology (p. 471)[SP\_53\_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

**Learning Control / Examinations**

oral examination; duration: 20 minutes

**Conditions**

None.

**Recommendations**

- Fundamentals of fluid dynamics

**Learning Outcomes**

After completing the course students should be able to establish a connection between theory and numerical modeling of turbulent flows.

**Content**

This course is specified for Master students of Mechanical, Power and Nuclear Engineering. The problem of turbulence is of key importance in many fields of science and engineering. It is an area which is vigorously researched across a diverse range of disciplines. This course is aimed of giving the fundamentals of turbulence theory and modelling. Starting from the basic physical phenomena and governing equations the quantitative and statistical description of turbulence is introduced. An overview on computational methods for turbulent flows and turbulence modelling is given.

**Course: Materials under high thermal or neutron loads [2194650]****Coordinators:** A. Möslang, M. Rieth**Part of the modules:** SP 53: Fusion Technology (p. 471)[SP\_53\_mach], SP 21: Nuclear Energy (p. 433)[SP\_21\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral Examination (20 min)

**Conditions**

Materials science I

**Recommendations**

none

**Learning Outcomes**

Advanced structural and functional materials for thermally or neutronically highly loaded systems. The students learn property profiles, applications and the interaction between atomic structure, microstructure and macroscopic materials behaviour.

**Content**

- Introduction and basics
- Metallic and ceramic solid state structure
- Transport of matter and conversion in solid state
- Material properties at high heat loads
- Interaction between energetic particles and condensed matter, irradiation damage
- Nanoscaled modelling of damage relevant properties
- State-of-the-art analytical methods with particles
- Highly heat resistant Steels
- Nanoscaled, oxide dispersion strengthened alloys
- Super alloys
- Refractory metals and laminates
- Fibre reinforced structural ceramics
- Light high strength Beryllium alloys
- Oxides and functional materials
- Joining technologies
- Strategies of materials development
- Applications in Fusion, fission, large scale accelerators and concentrated solar power

**Literature**

Presentation with figures and tables, Exercise sheets

**Course: Computational methods for the heat protection of a full vehicle [2157445]****Coordinators:** H. Reister**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 05: Calculation Methods in Mechanical Engineering (p. 417)[SP\_05\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach], (p. 475)[SP\_58\_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination, 30 minutes, no aids

**Conditions**

basics in fluid mechanics and thermodynamics recommended

**Recommendations**

none

**Learning Outcomes**

The students have basic equations to understand thermal situation in vehicles.

They can evaluate thermal situation in vehicles.

The students can utilize methods.

**Content**

In the lecture computational methods for the heat protection of the full vehicle are presented. For this the basic conservation equations are introduced and the applied computational programs are discussed in detail. The aspects concerning fluid mechanics are treated extensively. For this the underhood flow as well as the flow around the vehicle, at the underbody and at the rear of the car are considered. The computation of the temperature in the components of the vehicle is illustrated. For this mainly local approaches for the classical and electronic components are used. Finally a new overall approach for the heat protection is explained where also detailed computations at the engine, at the exhaust system and at the transmission are integrated.

Content

1. Introduction
2. Theoretical fundamentals
3. Computational methods
4. Numerical simulation of the flow in and around the vehicle
5. Computation of the temperature in components
6. Overall approach for the heat protection

**Course: Thermal Solar Energy [2169472]****Coordinators:** R. Stieglitz**Part of the modules:** SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 25 minutes

no tools or reference materials may be used during the exam

**Conditions**

Basics in heat and mass transfer, material science and fluid mechanics

**Recommendations**

desirable are reliable knowledge in physics in optics and thermodynamics

**Learning Outcomes**

The lecture elaborates the basics of the solar technology and the definition of the major wordings and its physical content such as radiation, thermal use, insulation etc.. Further the design of solar collectors for different purposes is discussed and analyzed. The functional principle of solar plants is elaborated before at the end the ways for solar climatization is discussed.

The aim of the course is to provide the basic physical principles and the derivation of key parameters for the individual solar thermal use. This involves in addition to the selective absorber, mirrors, glasses, and storage technology. In addition, a utilization of solar thermal energy means an interlink of the collector with a thermal-hydraulic circuit and a storage. The goal is to capture the regularities of linking to derive efficiency correlations as a function of their use and evaluate the performance of the entire system.

**Content**

Basics of thermal solar energy (radiation, heat conduction, storage, efficiency ...) Active and passive use of solar energy. Solar collectors (design types, efficiency, system technology). Solar plants (heliostats etc.). Solar climatization.

In detail:

- 1 Introduction to energy requirements and evaluation of the potential use of solar thermal energy.
- 2 Primary energy sources SUN: sun, solar constant, radiation (direct, diffuse scattering, absorption, impact angle, radiation balance).
- 3 Solar panels: schematic structure of a collector, fundamentals of efficiency, meaning of concentration and their limitations.
- 4 Passive solar mechanisms: heat conduction in solids and gases, radiation heat transfer in transparent and opaque bodies, selective absorber - typical materials and manufacturing processes.
- 5 Momentum and heat transport: basic equations of single and multiphase transport, calculation methods, stability limits.

optional

6 Low temperature solar thermal systems: Collector variants, methods for system simulation, planning and dimensioning of systems, system design and arrest scenarios.

6 High temperature solar thermal systems: solar towers and solar-farm concept, loss mechanisms, chimney power plants and energy production processes

end

- Memory: energy content, storage types, storage materials, cost
- Solar Air Conditioning: Cooling capacity determination, climate, solar cooling method and evaluation of air conditioning.

**Literature**

supply of lecture material in printed and electronic form

Stieglitz & Heinzel; Thermische Solarenergie -Grundlagen-Technologie- Anwendungen. Springer Vieweg Verlag. 711 Seiten. ISBN 978-3-642-29474-7

**Course: Thermal Turbomachines I [2169453]****Coordinators:** H. Bauer**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Winter term | en                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 min

no tools or reference materials may be used during the exam

**Conditions**

None.

**Recommendations**

It is a recommended lecture combination with 'Thermal Turbomachines II'.

**Learning Outcomes**

The students are able to explain and comment on the design and operation of thermal turbomachines in detail. Moreover, they can evaluate the range of applications for turbomachinery. Therefore, students are able to describe and analyse not only the individual components but also entire assemblies. The students can assess and evaluate the effects of physical, economical and ecological boundary conditions.

**Content**

Basic concepts of thermal turbomachinery

Steam Turbines - Thermodynamic process analysis

Gas Turbines - Thermodynamic process analysis

Combined cycle and cogeneration processes

Overview of turbomachinery theory and kinematics

Energy transfer process within a turbine stage

Types of turbines (presented through examples)

1-D streamline analysis techniques

3-D flow fields and radial momentum equilibrium in turbines

Compressor stage analysis and future trends in turbomachinery

**Literature**

Lecture notes (available via Internet)

Bohl, W.: Strömungsmaschinen, Bd. I, II; Vogel Verlag, 1990, 1991

Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993

Traupel, W.: Thermische Turbomaschinen Bd. I, II, Springer-Verlag, 1977, 1982

**Course: Thermal Turbomachines II [2170476]****Coordinators:** H. Bauer**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 3              | Summer term | en                   |

**Learning Control / Examinations**

oral (can only be taken in conjunction with 'Thermal Turbomachines I')  
 Duration: approx. 30 min (→ 1 hour including Thermal Turbomachines I)

Auxiliary: no tools or reference materials may be used during the exam

**Conditions**

None.

**Recommendations**

Recommended as lecture combination with 'Thermal Turbomachines I'.

**Learning Outcomes**

Based on the fundamental skills learned in 'Thermal Turbomachines I' the students have the ability to design turbines and compressors and to analyse the operational behavior of these machines.

**Content**

General overview, trends in design and development

Comparison turbine - compressor

Integrating resume of losses

Principal equations and correlations in turbine and compressor design, stage performance

Off-design performance of multi-stage turbomachines

Control system considerations for steam and gas turbines

Components of turbomachines

Critical components

Materials for turbine blades

Cooling methods for turbine blades (steam and air cooling methods)

Short overview of power plant operation

Combustion chamber and environmental issues

**Literature**

Course not packet

Bohl, W.: Strömungsmaschinen, Bd. I,II, Vogel Verlag 1990, 1991

Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993

Traupel, W.: Thermische Turbomaschinen, Bd. I,II, Springer-Verlag, 1977, 1982

## Course: Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises) [2193002]

**Coordinators:** H. Seifert, D. Cupid

**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

Oral examination (30 min)

### Conditions

- basic course in materials science and engineering
- physical chemistry

### Recommendations

none

### Learning Outcomes

The students know the heterogeneous phase equilibria of binary, ternary and multicomponent materials systems. They can analyze the thermodynamic properties of multiphase engineering materials and their reactions with gas and liquid phases.

### Content

1. Binary phase diagrams
2. Ternary phase diagrams
  - Complete solubility
  - Eutectic systems
  - Peritectic systems
  - Systems with transition reactions
  - Systems with intermetallic phases
3. Thermodynamics of solution phases
4. Materials reactions involving pure condensed phases and a gaseous phase
5. Reaction equilibria in systems containing components in condensed solutions
6. Thermodynamics of multicomponent multiphase materials systems
7. Calculation of Phase Diagrams (CALPHAD)

### Literature

1. Phase Equilibria, Phase Diagrams and Phase Transformations, Their Thermodynamic Basis; M. Hillert, University Press, Cambridge (2007)
2. Introduction to the Thermodynamics of Materials; D.R. Gaskell, Taylor & Francis (2008)

**Course: Thin film and small-scale mechanical behavior [2178123]****Coordinators:** O. Kraft, P. Gruber**Part of the modules:** SP 56: Advanced Materials Modelling (p. 474)[SP\_56\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations****Conditions**

None.

**Learning Outcomes****Content**

**Course: Tractors [2113080]****Coordinators:** M. Kremmer**Part of the modules:** SP 34: Mobile Machines (p. 451)[SP\_34\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral examination

**Conditions**

basic knowledge in mechanical engineering

**Learning Outcomes**

After completion of the course the Students know:

- important problems in agritechnological developments
- Customer requirements and their implementation in tractors
- Tractor technology in width and depth

**Content**

Tractors are one of the most underestimated vehicles in regard to performance und technics. Almost none vehicle is as multifunctional and fulfilled with high-tec as a tractor. Automatic guidance, special chassis suspension or special concepts of power trains are one of the topics where tractors are in leading position in technologies

During the lecture an overview about the design and construction and application area is given. A close look will be taken on the historical background, legal requirements, ways of development, agricultural organizations and the proces of development itself.

In detail the following topics will be dealt with:

- agricultural organization / legal requirements
- history of tractors
- tractor engineering
- tractor mechanics
- chassis suspension
- combustion engine
- transmission
- interfaces
- hydraulics
- wheels and tyres
- cabin
- electrics and electronics

**Literature**

- K.T. Renius: Traktoren - Technik und ihre Anwendung; DLG Verlag (Frankfurt), 1985
- E. Schilling: Landmaschinen - Lehr- und Handbuch für den Landmaschinenbau; Schilling-Verlag (Köln), 1960

**Course: Tribology [2181114]****Coordinators:** M. Scherge, M. Dienwiebel**Part of the modules:** (p. 475)[SP\_58\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach], SP 47: Tribology (p. 466)[SP\_47\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 4              | Winter term |                      |

**Learning Control / Examinations**

oral examination (30 min)

no tools or reference materials

**Conditions**

None.

**Recommendations**

preliminary knowlegde in mathematics, mechanics and materials science

**Learning Outcomes**

The student can

- describe the fundamental friction and wear mechanisms, which occur in tribologically stressed systems.
- evaluate the friction and wear behavior of tribological systems.
- explain the effects of lubricants and their most important additives
- identify suitable approaches to optimize tribological systems.

**Content**

- Chapter 1: Friction Adhesion, geometrical and real area of contact, Friction experiments, friction powder, tribological stressing, environmental influences, tribological age, contact models, Simulation of contacts, roughness.
- Chapter 2: Wear, plastic deformation at the asperity level, dissipation modes, mechanical mixing, Dynamics of the third body, running-in, running- in dynamics, shear stress.
- Chapter 3: Lubrication, base oils, Stribeck plot, lubrication regimes (HD, EHD, mixed lubrication), additives, oil characterization, solid lubrication.

**Literature**

1. Fleischer, G. ; Gröger, H. ; Thum: Verschleiß und Zuverlässigkeit. 1. Auflage. Berlin : VEB-Verlag Technik, 1980
2. Persson, B.J.N.: Sliding Friction, Springer Verlag Berlin, 1998
3. M. Dienwiebel, and M. Scherge, Nanotribology in automotive industry, In:Fundamentals of Friction and Wear on the Nanoscale; Editors: E. Meyer and E. Gnecco, Springer, Berlin, 2007.
4. Scherge, M., Shakhvorostov, D., Pöhlmann, K.: Fundamental wear mechanism of metals. Wear 255, 395–400 (2003)
5. Shakhvorostov, D., Pöhlmann, K., Scherge, M.: An energetic approach to friction, wear and temperature. Wear 257, 124–130 (2004)

**Course: Turbine and compressor Design [2169462]****Coordinators:** H. Bauer, A. Schulz**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

Thermal Turbomachines I+II

**Learning Outcomes**

The students have the ability to:

- 
- describe special types of components, such as e.g. radial machines and transonic compressors
- explain and evaluate the operation of components and machines
- interpret and apply the the physical principles
- design individual components in a practical approach

**Content**

The lecture is intended to expand the knowledge from Thermal Turbomachines I+II.  
Thermal Turbomaschines, general overview

Design of a turbomachine: Criteria and development

Radial machines

Transonic compressors

Combustion chambers

Multi-spool installations

**Literature**

Münzberg, H.G.: Gasturbinen - Betriebsverhalten und Optimierung, Springer Verlag, 1977

Traupel, W.: Thermische Turbomaschinen, Bd. I-II, Springer Verlang, 1977, 1982

**Course: Turbo Jet Engines [2170478]****Coordinators:** H. Bauer, A. Schulz**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

The students have the ability to:

- 
- compare the design concepts of modern jet engines
- analyse the operation of modern jet engines
- apply the thermodynamic and fluidmechanic basics of jet engines
- choose the main components intake, compressor, combustor, turbine and thrust nozzle based on given criteria
- comment on different methods for the reduction of pollutant emissions, noise and fuel consumption

**Content**

Introduction to jet engines and their components

Demands on engines and propulsive efficiency

Thermodynamic and gas dynamic fundamentals and design calculations

Components of air breathing engines

Jet engine design and development process

Engine and component design

Current developments in the jet engines industry

**Literature**

Hagen, H.: Fluggasturbinen und ihre Leistungen, G. Braun Verlag, 1982

Hünnecke, K.: Flugtriebwerke, ihre Technik und Funktion, Motorbuch Verlag, 1993

Saravanamuttoo, H.; Rogers, G.; Cohen, H.: Gas Turbine Theory, 5th Ed., 04/2001

Rolls-Royce: The Jet Engine, ISBN:0902121235, 2005

**Course: Tutorial for Heat Transfer in Nuclear Reactors [2189901]****Coordinators:** X. Cheng**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 1            | 1              | Winter / Summer Term | en                   |

**Learning Control / Examinations**

- Exam together with the course „Nuclear Thermal-Hydraulics“
- Results from the exercise with sub-channel analysis program

**Conditions**

None.

**Learning Outcomes**

The goal of the lecture is to

- Improve the understanding of the course „nuclear thermal-hydraulics“
- Demonstrate practical examples of flow and heat transfer in reactor core
- Exercise the application of a sub-channel program for reactor core design analysis

**Content**

- About 5-7 exercises to calculate: heat source distribution, pressure drop, heat transfer, temperature distribution in reactor core, critical heat flux, natural convection capability etc.
- Exercise with sub-channel program

**Course: Metal Forming [2150681]****Coordinators:** T. Herlan**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The students

- are able to reflect the basics, forming processes, tools, Machines and equipment of metal forming in an integrated and systematic way.
- are capable to illustrate the differences between the forming processes, tools, machines and equipment with concrete examples and are qualified to analyze and assess them in terms of their suitability for the particular application.
- are also able to transfer and apply the acquired knowledge to other metal forming problems.

**Content**

At the beginning of the lecture the basics of metal forming are briefly introduced. The focus of the lecture is on massive forming (forging, extrusion, rolling) and sheet forming (car body forming, deep drawing, stretch drawing). This includes the systematic treatment of the appropriate metal forming Machines and the corresponding tool technology.

Aspects of tribology, as well as basics in material science and aspects of production planning are also discussed briefly. The plastic theory is presented to the extent necessary in order to present the numerical simulation method and the FEM computation of forming processes or tool design. The lecture will be completed by product samples from the forming technology.

The topics are as follows:

- Introduction and basics
- Hot forming
- Metal forming machines
- Tools
- Metallographic fundamentals
- Plastic theory
- Tribology
- Sheet forming
- Extrusion
- Numerical simulation

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

**Course: Vehicle Ride Comfort & Acoustics I [2114856]****Coordinators:** F. Gauterin**Part of the modules:** SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

**Conditions**

Examination in english

Can not be combined with lecture [2113806]

**Recommendations**

none

**Learning Outcomes**

The students know what noises and vibrations mean, how they are generated, and how they are perceived by human beings.

They have knowledge about the requirements given by users and the public. They know which components of the vehicle are participating in which way on noise and vibration phenomenon and how they could be improved. They are ready to apply different tools and methods to analyze relations and to judge them. They are able to develop the chassis regarding driving comfort and acoustic under consideration of goal conflicts.

**Content**

1. Perception of noise and vibrations
3. Fundamentals of acoustics and vibrations
3. Tools and methods for measurement, computing, simulation and analysis of noise and vibrations
4. The relevance of tire and chassis for the acoustic and mechanical driving comfort: phenomena, influencing parameters, types of construction, optimization of components and systems, conflict of goals, methods of development

An excursion will give insights in the development practice of a car manufacturer or a system supplier.

**Literature**

1. Michael Möser, Technische Akustik, Springer, Berlin, 2005
2. Russel C. Hibbeler, Technische Mechanik 3, Dynamik, Pearson Studium, München, 2006
3. Manfred Mitschke, Dynamik der Kraftfahrzeuge, Band B: Schwingungen, Springer, Berlin, 1997

The script will be supplied in the lectures

**Course: Vehicle Ride Comfort & Acoustics II [2114857]****Coordinators:** F. Gauterin**Part of the modules:** SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

**Conditions**

Examination in english

Can not be combined with lecture [2114825]

**Recommendations**

none

**Learning Outcomes**

The students have knowledge about the noise and vibration properties of the chassis components and the drive train. They know what kind of noise and vibration phenomena do exist, what are the generation mechanisms behind, which components of the vehicle participate in which way and how could they be improved. They have knowledge in the subject area of noise emission of automobiles: Noise impact, legal requirements, sources and influencing parameters, component and system optimization, target conflicts and development methods. They are ready to analyze, to judge and to optimize the vehicle with its single components regarding acoustic and vibration phenomena. They are also able to contribute competently to the development of a vehicle regarding the noise emission.

**Content**

- Summary of the fundamentals of acoustics and vibrations
- The relevance of road surface, wheel imperfections, springs, dampers, brakes, bearings and bushings, suspensions, engines and drive train for the acoustic and mechanical driving comfort:
  - phenomena
  - influencing parameters
  - types of construction
  - optimization of components and systems
  - conflicts of goals
  - methods of development
- Noise emission of motor vehicles
  - noise stress
  - sound sources and influencing parameters
  - legal restraints
  - optimization of components and systems
  - conflict of goals
  - methods of development

**Literature**

The script will be supplied in the lectures.

**Course: Combustion diagnostics [2167048]****Coordinators:** R. Schießl, U. Maas**Part of the modules:** SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 2              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

After completing this course students can:

- 
- understand the specific requirements for diagnostic techniques in combustion applications.
- explain the physical fundamentals of diagnostic techniques, in particular of laser diagnostics.
- assess the potentials and the limits of the different diagnostic methods.

**Content**

Diagnostical methods: Laser induced fluorescence, Rayleigh-scattering, Raman-scattering  
Chemoluminescence.

Reduced description of combustion processes and measurements.

Discussion of the potential and limits of specific strategies in different combustion systems.

**Literature**

Lecture notes

A.C. Eckbreth, Laser Diagnostics for Combustion Temperature and Species,  
Abacus Press, 2nd ed. (1996)

W. Demtröder, Laser Spectroscopy: Basic Concepts and Instrumentation,  
Springer, 3rd ed., 2003

Hollas J.M. Modern Spectroscopy, Wiley, 3rd ed., 1996

K. Kohse-Höinghaus, J. B. Jeffries (ed.), Applied Combustion Diagnostics,  
Taylor and Francis

Atkins P., Paula, J., Physical Chemistry, 8th ed., Oxford University Press,  
2006

**Course: Behaviour Generation for Vehicles [2138336]****Coordinators:** C. Stiller, T. Dang**Part of the modules:** SP 18: Information Technology (p. 430)[SP\_18\_mach], SP 22: Cognitive Technical Systems (p. 434)[SP\_22\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 34: Mobile Machines (p. 451)[SP\_34\_mach], SP 44: Technical Logistics (p. 463)[SP\_44\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 30 minutes

no reference materials

**Conditions**

Fundamentals in measurement, system and control theory, e.g. from the lecture "Measurement and Control Systems"

**Learning Outcomes**

Modern vehicle control systems like ABS or ESP transform the intention of the driver into a corresponding behaviour of the vehicle. This is achieved by compensating disturbances like a varying traction for example. Within the recent years, vehicles have been increasingly equipped with sensors that gather information about the environment (Radar, Lidar and Video for example). This enables the vehicles to generate an 'intelligent' behaviour and transform this behaviour into control signals for actors. Several so called 'driver assistance systems' have already achieved remarkable improvements as far as comfort, safety and efficiency are concerned. But nevertheless, several decades of research will be required to achieve an automated behaviour with a performance equivalent to a human operator ('the driver'). The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Information technology, control theory and kinematic aspects are treated to provide a broad overview over vehicle guidance. Application examples from cutting-edge and future driver assistance systems illustrate the discussed subjects.

**Content**

1. Driver assistance systems
2. Driving comfort and safety
3. Vehicle dynamics
4. Path and trajectory planning
5. Path control
6. Collision avoidance

**Literature**

TBA

## Course: Failure of Structural Materials: Fatigue and Creep [2181715]

**Coordinators:** O. Kraft, P. Gumbsch, P. Gruber

**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

### Learning Control / Examinations

oral exam 30 minutes

no tools or reference materials

### Conditions

compulsory preconditions: none

### Recommendations

preliminary knowlegde in mathematics, mechanics and materials science

### Learning Outcomes

The student

- has the basic understanding of mechanical processes to explain the relationships between externally applied load and materials strength.
- can describe the main empirical materials models for fatigue and creep and can apply them.
- has the physical understanding to describe and explain phenomena of failure.
- can use statistical approaches for reliability predictions.
- can use its acquired skills, to select and develop materials for specific applications.

### Content

1 Fatigue

1.1 Introduction

1.2 Statistical Aspects

1.3 Lifetime

1.4 Fatigue Mechanisms

1.5 Material Selection

1.6 Thermomechanical Loading

1.7 Notches and Shape Optimization

1.8 Case Study: ICE-Desaster

2 Creep

2.1 Introduction

2.2 High Temperature Plasticity

2.3 Phänomenological DDescription of Creep

2.4 Creep Mechanisms

2.5 Alloying Effects

### Literature

- Engineering Materials, M. Ashby and D.R. Jones (2nd Edition, Butterworth-Heinemann, Oxford, 1998); worth reading, relatively simple but comprehensive
- Mechanical Behavior of Materials, Thomas H. Courtney (2nd Edition, McGraw Hill, Singapur); classic on the mechanical behavior of materials, extensive and good
- Bruchvorgänge in metallischen Werkstoffen, D. Aurich (Werkstofftechnische Verlagsgesellschaft Karlsruhe), relatively simple but yet comprehensive overview of metallic materials

Master Program

Mechanical Engineering (M.Sc.)

Module Handbook, Date: 10/01/2014

- Fatigue of Materials, Subra Suresh (2nd Edition, Cambridge University Press); standard work on fatigue, all classes of materials, extensive, for beginners and advanced student

**Course: Failure of structural materials: deformation and fracture [2181711]****Coordinators:** P. Gumbsch, O. Kraft, D. Weygand**Part of the modules:** SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach], SP 43: Technical Ceramics and Powder Materials (p. 462)[SP\_43\_mach], SP 02: Powertrain Systems (p. 414)[SP\_02\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**oral exam 30 minutes  
no tools or reference materials**Conditions**

compulsory preconditions: none

**Recommendations**

preliminary knowlegde in mathematics, mechanics and materials science

**Learning Outcomes**

The student

- has the basic understanding of mechanical processes to explain the relationship between externally applied load and materials strength.
- can explain the foundation of linear elastic fracture mechanics and is able to determine if this concept can be applied to a failure by fracture.
- can describe the main empirical materials models for deformation and fracture and can apply them.
- has the physical understanding to describe and explain phenomena of failure.

**Content**

1. Introduction
2. linear elasticity
3. classification of stresses
4. Failure due to plasticity
  - tensile test
  - dislocations
  - hardening mechanisms
  - guidelines for dimensioning
5. composite materials
6. fracture mechanics
  - hypotheses for failure
  - linear elastic fracture mechanics
  - crack resistance
  - experimental measurement of fracture toughness
  - defect measurement
  - crack propagation

- application of fracture mechanics
- atomistics of fracture

**Literature**

- Engineering Materials, M. Ashby and D.R. Jones (2nd Edition, Butterworth-Heinemann, Oxford, 1998); worth reading, relatively simple but comprehensive
- Mechanical Behavior of Materials, Thomas H. Courtney (2nd Edition, McGraw Hill, Singapur); classic on the mechanical behavior of materials, extensive and good
- Bruchvorgänge in metallischen Werkstoffen, D. Aurich (Werkstofftechnische Verlagsgesellschaft Karlsruhe), relatively simple but yet comprehensive overview of metallic materials

**Course: Gear Cutting Technology [2149655]****Coordinators:** M. Klaiber**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The assessment is carried out as an oral examination. The examination is offered every winter semester in agreement with the Lecturer.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The students . . .

- can describe the basic terms of gearings and are able to explain the imparted basics of the gearwheel and gearing theory.
- are able to specify the different manufacturing processes and machine technologies for producing gearings. Furthermore they are able to explain the functional principles and the dis-/advantages of these manufacturing processes.
- can apply the basics of the gearing theory and manufacturing processes on new problems.
- are able to read and interpret measuring records for gearings.
- are able to make an appropriate selection of a process based on a given application
- can describe the entire process chain for the production of toothed components and their respective influence on the resulting workpiece properties.

**Content**

Based on the gearing theory, manufacturing processes and machine technologies for producing gearings, the needs of modern gear manufacturing will be discussed in the lecture. For this purpose, various processes for various gear types are taught which represent the state of the art in practice today. A classification in soft and hard machining and furthermore in cutting and non-cutting technologies will be made. For comprehensive understanding the processes, machine technologies, tools and applications of the manufacturing of gearings will be introduced and the current developments presented. For assessment and classification of the applications and the performance of the technologies, the methods of mass production and manufacturing defects will be discussed. Sample parts, reports from current developments in the field of research and an excursion to a gear manufacturing company round out the lecture.

The following topics will be covered:

- Sample applications
- Basics of gearing geometry
- Need of gearboxes
- Soft machining processes
- Hardening processes
- Hard machining processes
- Bevel gear production

- Measurement and testing
- Manufacturing of gearbox components
- Special gearings

**Media**

Lecture slides will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Slides

**Remarks**

None

**Course: Virtual Engineering I [2121352]****Coordinators:** J. Ovtcharova**Part of the modules:** SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 6            | 5              | Winter term | de                   |

**Learning Control / Examinations**

Depending on choice according to actual version of study regulations

Duration: 30 min

Auxiliary Means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students can:

- rename and explain the basic methods of virtual engineering and the typical problems in product development.
- associate the methods and problems of the corresponding phases of the product life cycle and derive the necessary interfaces.
- select the appropriate IT systems for given problems and evaluate their suitability for the support of management's approach PLM.
- apply CAD/CAx/PLM-Systems using simple exercises.

**Content**

The lecture presents the informational interrelationship required for understanding the virtual product development process. For this purpose, an emphasis and focus will be placed on IT-systems used in the industrial sector as support for the process chain of virtual engineering:

- Product Lifecycle Management refers to the entire lifecycle of the product, beginning with the concept phase up through disassembling and recycling.
- CAx-systems for the virtual product development allow the modeling of a digital product in regards to design, construction, manufacturing and maintenance.
- Validation Systems allow the checking of the product in regard to static, dynamics, safety and build ability.

The goal of the lecture is to clarify the relationship between construction and validation operations through the usage of virtual prototypes and VR/AR/MR visualisation techniques in connection with PDM/PLM-systems. This will be achieved through an introduction to each particular system along with praxis-oriented exercises.

**Literature**

Lecture slides

**Course: Virtual Engineering II [2122378]****Coordinators:** J. Ovtcharova**Part of the modules:** SP 09: Dynamic Machine Models (p. 422)[SP\_09\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 3              | Summer term | de                   |

**Learning Control / Examinations**

Depending on choice according to actual version of study regulations

Auxiliary Means: none

**Conditions**

None.

**Recommendations**

None.

**Learning Outcomes**

The students will be able to:

- describe virtual reality, how the stereoscopic effect occurs and compare the technologies to simulate this effect.
- describe how to model a scene in VR, store the VR graph on a computer and explain the inner workings of the VR pipeline for visualizing the scene.
- name various systems for interacting with the VR scene and assess the advantages and disadvantages of various manipulation and tracking devices.
- compare validation tests that can be carried through in the product development process with the aid of a virtual mock-up (VMU) and describe the difference between a VMU, a physical mock-up (PMU) and a virtual prototype (VP).
- point out the vision of an integrated virtual product development and which challenges need to be resolved towards that vision.

**Content**

The lecture presents the informational interrelationship required for understanding the virtual product development process. For this purpose, an emphasis and focus will be placed on IT-systems used in the industrial sector as support for the process chain of virtual engineering:

- The corresponding models can be visualized in Virtual Reality Systems, from single parts up through a complete assembly.
- Virtual Prototypes combine CAD-data as well as information about the remaining characteristics of the components and assembly groups for immersive visualisation, functionality tests and functional validations in the VR/AR/MR environment.
- Integrated Virtual Product Development exemplified the product development process from the point of view of Virtual Engineering.

The goal of the lecture is to clarify the relationship between construction and validation operations through the usage of virtual prototypes and VR/AR/MR visualisation techniques in connection with PDM/PLM-systems. This will be achieved through an introduction to each particular IT-system along with praxis-oriented exercises.

**Literature**

Lecture slides

**Course: Virtual Reality Laboratory [2123375]****Coordinators:** J. Ovtcharova**Part of the modules:** SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 28: Lifecycle Engineering (p. 443)[SP\_28\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 31: Mechatronics (p. 446)[SP\_31\_mach], SP 40: Robotics (p. 458)[SP\_40\_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 442)[SP\_27\_mach]

| ECTS Credits | Hours per week | Term                 | Instruction language |
|--------------|----------------|----------------------|----------------------|
| 4            | 3              | Winter / Summer Term | de                   |

**Learning Control / Examinations**

Presentation of project work (40%)  
 Individual project participation (30%)  
 Written test (20%)  
 Soft skills (10%)

**Conditions**

None

**Recommendations**

Participation in the course Virtual Engineering 2 [2122378]

**Learning Outcomes**

The students are able to operate and use hardware and software for Virtual Reality applications in order to:

- design solutions for complex tasks in a team.
- solve subtasks within a specific work package in small groups, keeping the interfaces to other work packages in mind and
- merge this solution in the final product.

**Content**

The Virtual Reality lab course consists of following three overlapping parts:

- Basics: Introduction in Virtual Reality (hardware, software, applications)
- Tool Kit: Exercises in the task specific software systems
- Application: autonomous project work in the area of Virtual Reality in small groups

Soft Skills: Methodical approach to practical engineering problems, team and interdisciplinary work, time management.

**Media**

Stereoscopic projection in MR and VR at the Lifecycle Engineering Solutions Center (LESC), 15 computers, beamer

**Literature**

Presentations, Exercise documents, Tutorials, Books for individual work

**Course: Heatpumps [2166534]****Coordinators:** H. Wirbser, U. Maas**Part of the modules:** SP 45: Engineering Thermodynamics (p. 464)[SP\_45\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral

Duration: 30 min.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The attendance of this course enables students to:

- 
- describe the setup and the working principle of heat pumps.
- specify the various types of heat pumps.
- analyse the energetic requirements.
- asses the advantages and drawbacks of heat pumps as heating system.

**Content**

The aim of this lecture is to promote heat pumps as heating systems for small an medium scale facilities and to discuss their advantages as well as their drawbacks. After considering the actual energy situation and the political requirements the different aspects of heat pumps are elucidated. The requirements concerning heat sources, the different components and the various types of heat pumps are discussed. In addition ecological and economical aspects are taken into consideration. The coupling of heat pumps with heat accumulators in heating systems will also be part of the lecture.

**Literature**

Vorlesungsunterlagen

Bach, K.: Wärmepumpen, Bd. 26 Kontakt und Studium, Lexika Verlag, 1979

Kirn, H., Hadenfeldt, H.: Wärmepumpen, Bd. 1: Einführung und Grundlagen, Verlag C. F. Müller, 1987

von Cube, H.L.: Lehrbuch der Kältetechnik, Verlag C.F. Müller, Karlsruhe, 1975.

von Cube, H.L., Steimle,F.: Wärmepumpen, Grunlagen und Praxis VDI-Verlag, Düsseldorf, 1978.

**Course: Heat Transfer in Nuclear Reactors [2189907]****Coordinators:** X. Cheng**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | en                   |

**Learning Control / Examinations**

oral examination; duration: 20 minutes

**Conditions**

None.

**Learning Outcomes**

This lecture is focused on students of mechanical engineering and chemical engineering in bachelor or master degree courses. The students learn important processes and methods of heat transfer nuclear reactors. Exercises with numerical simulationa programs will enhance the understanding.

**Content**

1. Overview of nuclear systems
2. Design tasks and design criteria of nuclear thermal-hydraulics
3. Heat release and distribution in nuclear reactors
4. Heat transfer process in nuclear reactors
5. Temperature distribution in coolant and structural materials
6. Pressure drops in nuclear systems
7. Flow stability of nuclear systems
8. Critical flow under accident conditions
9. Natural circulation and passive safety systems
10. Methodologies of thermal-hydraulic design

**Literature**

1. W. Oldekop, Einführung in die Kernreaktor und Kernkraftwerkstechnik, Verlag Karl Thiemeig, München, 1975
2. L.S. Tong, J. Weisman, Thermal-hydraulics of pressurized water reactors, American Nuclear Society, La Grande Park, Illinois, USA
3. R.T. Lahey, F.J. Moody, The Thermal-Hydraulics of a Boiling Water Nuclear Reactor, 2nd edition, ANS, La Grande Park, Illinois, USA, 1993

**Course: Hydrogen Technologies [2170495]****Coordinators:** T. Jordan**Part of the modules:** SP 23: Power Plant Technology (p. 435)[SP\_23\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

Auxiliary: no tools or reference materials may be used during the exam

**Conditions**

None.

**Learning Outcomes**

The course content is the cross-cutting issue of hydrogen as energy carrier. The basic hydrogen technologies will be presented in order to analyse and substantiate the idea of a hydrogen economy. The physical properties of hydrogen will be introduced. The production, distribution, storage and applications are explained. The latter comprise hydrogen utilization in combustion engines and in fuel cells. The safety aspects will be treated as a cross-cutting issue by comparing with hazards of conventional energy carriers.

**Content**

Basic concepts

Production

Transport and storage

Application

Safety aspects

**Literature**

Ullmann's Encyclopedia of Industrial Chemistry

<http://www.hysafe.net/BRHS>

**Course: Wave Propagation [2161219]****Coordinators:** W. Seemann**Part of the modules:** SP 04: Automation Technology (p. 416)[SP\_04\_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 425)[SP\_11\_mach], SP 08: Dynamics and Vibration Theory (p. 421)[SP\_08\_mach], SP 01: Advanced Mechatronics (p. 412)[SP\_01\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

Oral

30 minutes (optional subject), 20 minutes (major subject)

no means

**Conditions**

Vibration theory

**Learning Outcomes**

The course gives an introduction into wave propagation phenomena. This contains both one-dimensional continua (beams, rods, strings) as well as two- and three-dimensional continua. Initial condition problems are treated. Fundamental effects like phase velocity, group velocity or dispersion are explained. Wave propagation is used to show the limits of structural models like beams. In addition surface waves and acoustic waves are covered.

**Content**

Wave propagation in strings and rods, d'Alembert's solution, initial value problem, boundary conditions, excitation at the boundary, energy transport, wave propagation in beams, Bernoulli-Euler beams, group velocity, beams with changing cross-section, reflexion and transmission, Timoshenko beam theory, wave propagation in membranes and plates, acoustic waves, reflexion and refraction, spherical waves, s- and p-waves in elastic media, reflexion and transmission at bounding surfaces, surface waves

**Literature**

P. Hagedorn and A. Dasgupta: Vibration and waves in continuous mechanical systems. Wiley, 2007.

**Course: Material Analysis [2174586]****Coordinators:** J. Gibmeier**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral examination

duration: 20 - 30 minutes

no auxillary resources

**Conditions**

obligation: Material Science I/II

**Learning Outcomes**

The students have basic knowledge about methods of material analysis. They have a basic understanding to transfer this basic knowledge on problems in engineering science. Furthermore, the students have the ability to describe technical material by its microscopic and submicroscopic structure

**Content**

The following methods will be introduced within this module:

microscopic methods: optical microscopy, electron microscopy (SEM/TEM), atomic force microscopy

material and microstructure analyses by means of X-ray, neutron and electron beams

spectroscopic methods

**Literature**

lecture notes (will be provided at the beginning of the lecture)

literature will be quoted at the beginning of the lecture

**Course: Materials for Lightweight Construction [2174574]****Coordinators:** K. Weidenmann**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 12: Automotive Technology (p. 426)[SP\_12\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 46: Thermal Turbomachines (p. 465)[SP\_46\_mach], SP 25: Lightweight Construction (p. 438)[SP\_25\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

Oral examination

Duration: 20 - 30 Min

none

**Conditions**

Werkstoffkunde I/II (recommended)

**Learning Outcomes**

The students are capable to name different lightweight materials and can describe their composition, properties and fields of application. They can describe the hardening mechanisms of lightweight materials and can transfer this knowledge to applied problems.

The students can apply basic mechanical models of composites and can depict differences in the mechanical properties depending on composition and structure. The students can describe the basic principle of hybrid material concepts and can judge their advantages in comparison to bulk materials. The students can name special materials for lightweight design and depict differences to conventional materials. The students have the ability to present applications for different lightweight materials and can balance reasons for their use.

**Content**

Introduction

Constructive, production-oriented and material aspects of lightweight construction

Aluminium-based alloys  
Aluminium wrought alloys  
Aluminium cast alloys

Magnesium-based alloys  
Magnesium wrought alloys  
Magnesium cast alloys

Titanium-based alloys  
Titanium wrought alloys  
Titanium cast alloys

High-strength steels  
High-strength structural steels  
Heat-treatable and hardenable steels

Composites - mainly PMC  
Matrices  
Reinforcements

**Literature**

Presentation slides and additional lecture notes are handed out during the lecture, additional literature recommendations given

**Course: Materials Science and Engineering III [2173553]****Coordinators:** M. Heilmaier**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 5              | Winter term | de                   |

**Learning Control / Examinations**

oral; 30-40 minutes

**Conditions**

Basic knowledge in materials science and engineering (Werkstoffkunde I/II)

**Learning Outcomes**

The students are familiar with the thermodynamic foundations of phase transformations, the kinetics of phase transformations in the solid states (nucleation and growth phenomena), the mechanisms of microstructure formation and microstructure-property relationships and can apply them to metallic materials. They can assess the effects of heat treatments and of alloying on the microstructure and the properties of iron-based materials (steels in particular). They can select steels for structural applications in mechanical engineering and subject them to appropriate heat treatments.

**Content**

Properties of pure iron; thermodynamic foundations of single-component and of binary systems; nucleation and growth; diffusion processes in crystalline iron; the phase diagram Fe-Fe<sub>3</sub>C; effects of alloying on Fe-C-alloys; nonequilibrium microstructures; multicomponent iron-based alloys; heat treatment technology; hardenability and hardenability tests.

**Literature**

Lecture Notes; Problem Sheets; Bhadeshia, H.K.D.H. & Honeycombe, R.W.K.  
Steels – Microstructure and Properties  
CIMA Publishing, 3. Auflage, 2006

**Course: Materials modelling: dislocation based plasticity [2182740]****Coordinators:** D. Weygand**Part of the modules:** SP 26: Materials Science and Engineering (p. 440)[SP\_26\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Summer term | de                   |

**Learning Control / Examinations**

oral exam 30 minutes

**Conditions**

None.

**Recommendations**

preliminary knowlegde in mathematics, physics and materials science

**Learning Outcomes**

The student

- has the basic understanding of the physical basics to describe dislocations and their interaction with point, line and area defects.
- can apply modelling approaches for dislocation based plasticity.
- can explain discrete methods for modelling of microstructural evolution processes.

**Content**

1. Introduction
2. elastic fields of dislocations
3. slip, crystallography
4. equations of motion of dislocations
  - a) fcc
  - b) bcc
5. interaction between dislocations
6. discrete dislocation dynamics in two dimensions
7. discrete dislocation dynamics in three dimensions
8. continuum description of dislocations
9. microstructure evolution: grain growth
  - a) physical basis: small/large angle boundaries
  - b) interaction between dislocations and GBs
- 10) Monte Carlo methods in micro structure evolution

**Literature**

1. D. Hull and D.J. Bacon, Introduction to Dislocations, Oxford Pergamon 1994
2. J.P. Hirth and J. Lothe: Theory of dislocations, New York Wiley 1982. (oder 1968)
3. J. Friedel, Dislocations, Pergamon Oxford 1964.
4. V. Bulatov, W. Cai, Computer Simulations of Dislocations, Oxford University Press 2006
5. A.S. Argon, Strengthening mechanisms in crystal plasticity, Oxford materials.

**Course: Machine Tools and Industrial Handling [2149902]****Coordinators:** J. Fleischer**Part of the modules:** SP 39: Production Technology (p. 456)[SP\_39\_mach], SP 10: Engineering Design (p. 423)[SP\_10\_mach], SP 04: Automation Technology (p. 416)[SP\_04\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 8            | 6              | Winter term | de                   |

**Learning Control / Examinations**

The assessment is carried out as an oral exam. The examination is offered every semester. Reexaminations are offered at every ordinary examination date.

**Conditions**

None

**Recommendations**

None

**Learning Outcomes**

The students . . .

- are capable to explain the use and application of machine tools and handling devices as well as differentiate their characteristics and structure.
- are able to name and describe the essential components (frame, main spindles, feed axis, peripheral equipment, control) of machine tools.
- Are capable to distinguish and select and describe the essential components regarding structure, characteristics advantages and disadvantages.
- are enabled to dimension the main components of machine tools.
- are able to name and describe the control principles of machine tools.
- are capable to name examples of machine tools and industrial handling as well as to deduce compare the essential components. Additionally they can allocate manufacturing processes.
- are enabled to identify drawbacks as well as derive and asses measures for improvements.
- are qualified to apply methods for selection and evaluation of machine tools.
- are experienced to deduce the particular failure characteristics of a ball screw.

**Content**

The lecture provides an overview of machine tool and handling devices structures, use and application areas. Within the lecture based and industrially oriented knowledge for selection, dimensioning and evaluation is conveyed. First the components of machine tools are explained systematically. Here the distinctive features of dimensioning machine tools are deduced followed by the integral dimensioning of machine tools. Subsequently the use of machine tools is shown in exemplary application areas e.g. turning, milling, grinding, metal forming, sheet metal forming and gear cutting.

The lecture provides an inside view of industrial application and is illustrated with current examples.

The topics are as follows:

- Frame and frame components
- Main drives and main spindles
- Requirements for feed axes
- Electro-mechanical feed axis
- Fluidic feed axes

- Control technologies
- Peripheral components
- Metrological assessment
- Machine maintenance
- Process-diagnosis
- Machinery Directiv
- Machine tool examples

**Media**

Lecture notes will be provided in ilias (<https://ilias.studium.kit.edu/>).

**Literature**

Lecture Notes

**Remarks**

None

**Course: Wind and Hydropower [2157451]****Coordinators:** M. Gabi, N. Lewald**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | en                   |

**Learning Control / Examinations**

Written or Oral exam (according notice),  
 oral 30 minutes,  
 written 1,5 hours,  
 no means

**Conditions**

2157451 can not be combined with the courses 2157432 (Hydraulic Machinery 1) and 23381 (Windpower)

**Recommendations**

Fluid Mechanics

**Learning Outcomes**

The students know basic fundamentals for the use of wind- and hydropower.

**Content**

Wind- and Hydropower fundamental lecture. Introduction in the basics of fluid machinery.

**Windpower:**

Basic knowledge for the use of wind power for electricity, complemented by historical development, basic knowledge on wind systems and alternative renewable energies. Global and local wind systems as well as their measurement and energy content are dedicated. Aerodynamic basics and connections of wind-power plants and/or their profiles, as well as electrical system of the wind-power plants are described. Fundamental generator technology over control and controlling of the energy transfer.

Finally the current economic, ecological and legislations boundary conditions for operating wind-power plants are examined. An overview of current developments like super-grids and visions of the future of the wind power utilization will be given.

**Hydropower:**

Basic knowledge for the use of hydropower for electricity, complemented by historical development. Description of typical hydropower systems.

Introduction in the technology and different types of water turbines. Calculation of the energy conversion of typical hydropower systems.

**Literature**

- Erich Hau, Windkraftanlagen, Springer Verlag.
- J. F. Douglas et al., Fluid Mechanics, Pearson Education.
- Pfleiderer, Petermann, Strömungsmaschinen, Springer Verlag.
- Sandor O. Pálffy et al., Wasserkraftanlagen, Expert Verlag

**Course: Windpower [2157381]****Coordinators:** N. Lewald**Part of the modules:** SP 24: Energy Converting Engines (p. 437)[SP\_24\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 15: Fundamentals of Energy Technology (p. 428)[SP\_15\_mach], SP 55: Energy Technology for Buildings (p. 473)[SP\_55\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 3            | 2              | Winter term | de                   |

**Learning Control / Examinations**

The assessment consists of an oral exam (20 min) taking place at the beginning of the recess period (according to Section 4 (2), 2 of the examination regulation). The exam takes place in every winter semester. Re-examinations are offered at every ordinary examination date.

**Conditions**

None.

**Learning Outcomes**

The goal is to relay basic fundamentals for the use of wind power.

Wind Power fundamental lecture. Focus of the lecture is basic knowledge for the use of wind power for electricity, complemented by historical development, basic knowledge on wind systems and alternative renewable energies.

**Content**

The lecture contacts due to the broadly basic knowledge to all listeners of all terms.

On the basis of an overview of alternative, renewable energy technologies as well as general energy data, the entrance is transacted into the wind energy by means of an overview of the historical development of the wind force.

Since the wind supplies the driving power as indirect solar energy, the global and the local wind systems as well as their

measurement and energy content are dedicated to its own chapter.

Whereupon constructing the aerodynamic bases and connections of wind-power plants and/or their profiles are described. The electrical system of the wind-power plants forms a further emphasis. Begun of fundamental generator technology over control and controlling of the energy transfer.

After the emphasis aerodynamics and electrical system the further components of wind-power plants and their characteristics in the connection are described.

Finally the current economic, ecological and legislations boundary conditions for operating wind-power plants are examined.

In addition to wind-power plants for electricity production, the lecture is also shortly aiming at alternative use possibilities such as pumping systems.

Finally an overview of current developments like super-grids and visions of the future of the wind power utilization will be

given.

**Media**

A scriptum that has to be overhaul is available under [www.ieh.kit.edu](http://www.ieh.kit.edu) under "Studium und Lehre". Further book titles or relevant websites will be announced in the lecture.

**Course: Scientific computing for Engineers [2181738]****Coordinators:** D. Weygand, P. Gumbsch**Part of the modules:** SP 30: Applied Mechanics (p. 445)[SP\_30\_mach], SP 35: Modeling and Simulation (p. 452)[SP\_35\_mach], SP 49: Reliability in Mechanical Engineering (p. 467)[SP\_49\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral exam 30 minutes

**Conditions**

compulsory preconditions: none

**Learning Outcomes**

The student can

- apply the programming language C++ for scientific computing in the field of materials science
- adapt programs for use on parallel platforms
- choose suitable numerical methods for the solution of differential equations.

**Content**

1. Introduction: why scientific computing
2. computer architectures
3. Introduction to Unix/Linux
4. Foundations of C++
  - \* programm organization
  - \* data types, operator, control structures
  - \* dynamic memory allocation
  - \* functions
  - \* class
  - \* OpenMP parallelization
5. numeric /algorithms
  - \* finite differences
  - \* MD simulations: 2nd order differential equations
  - \* algorithms for particle simulations
  - \* solver for linear systems of eqns.

**Literature**

1. C++: Einführung und professionelle Programmierung; U. Breymann, Hanser Verlag München
2. C++ and object-oriented numeric computing for Scientists and Engineers, Daoqui Yang, Springer Verlag.
3. The C++ Programming Language, Bjarne Stroustrup, Addison-Wesley
4. Die C++ Standardbibliothek, S. Kuhlins und M. Schader, Springer Verlag

Numerik:

1. Numerical recipes in C++ / C / Fortran (90), Cambridge University Press
2. Numerische Mathematik, H.R. Schwarz, Teubner Stuttgart
3. Numerische Simulation in der Moleküldynamik, Griebel, Knapek, Zumbusch, Caglar, Springer Verlag

**Course: Two-Phase Flow and Heat Transfer [2169470]****Coordinators:** T. Schulenberg, M. Wörner**Part of the modules:** SP 21: Nuclear Energy (p. 433)[SP\_21\_mach], SP 53: Fusion Technology (p. 471)[SP\_53\_mach], SP 23: Power Plant Technology (p. 435)[SP\_23\_mach], SP 41: Fluid Mechanics (p. 460)[SP\_41\_mach]

| ECTS Credits | Hours per week | Term        | Instruction language |
|--------------|----------------|-------------|----------------------|
| 4            | 2              | Winter term | de                   |

**Learning Control / Examinations**

oral

Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

**Conditions**

Bachelor

**Learning Outcomes**

The students can describe two-phase flows with heat transfer as phenomena occurring in steam generators and condensers (e.g. in power stations or refrigerators). They can distinguish different flow regimes and transitions and apply two-phase flow models. The students are qualified to explain the characteristics of different flow examples (e.g. pressure drop of two phase flows, pool boiling, forced convective boiling, condensation) and can analyze two-phase flow instabilities.

**Content**

- Examples for technical applications
- Definitions and averaging of two-phase flows
- Flow regimes and transitions
- Two-phase models
- Pressure drop of two phase flows
- Pool boiling
- Forced convective boiling
- Condensation
- Two-phase flow instabilities

**Literature**

lecture notes



Universität Karlsruhe (TH) | Der Rektor  
Forschungsuniversität · gegründet 1825

# Amtliche Bekanntmachung

---

2008

Ausgegeben Karlsruhe, den 09. September 2008

Nr. 79

## Inhalt

Seite

Studien- und Prüfungsordnung der Universität Karlsruhe (TH) 374  
für den Masterstudiengang Maschinenbau

## **Studien- und Prüfungsordnung der Universität Karlsruhe (TH) für den Masterstudiengang Maschinenbau**

Aufgrund von § 34 Abs. 1, Satz 1 des Landeshochschulgesetzes (LHG) vom 1. Januar 2005 hat die beschließende Senatskommission für Prüfungsordnungen der Universität Karlsruhe (TH) am 31. Januar 2008 die folgende Studien- und Prüfungsordnung für den Masterstudiengang Maschinenbau beschlossen.

Der Rektor hat seine Zustimmung am 28. Februar 2008 erteilt.

### **Inhaltsverzeichnis**

#### **I. Allgemeine Bestimmungen**

- § 1 Geltungsbereich, Ziele
- § 2 Akademischer Grad
- § 3 Regelstudienzeit, Studienaufbau, Leistungspunkte
- § 4 Aufbau der Prüfungen
- § 5 Anmeldung und Zulassung zu den Prüfungen
- § 6 Durchführung von Prüfungen und Erfolgskontrollen
- § 7 Bewertung von Prüfungen und Erfolgskontrollen
- § 8 Erlöschen des Prüfungsanspruchs, Wiederholung von Prüfungen und Erfolgskontrollen
- § 9 Versäumnis, Rücktritt, Täuschung, Ordnungsverstoß
- § 10 Mutterschutz, Elternzeit
- § 11 Masterarbeit
- § 12 Berufspraktikum
- § 13 Zusatzmodule, Zusatzleistungen
- § 14 Prüfungskommission
- § 15 Prüferinnen und Beisitzende
- § 16 Anrechnung von Studienzeiten, Anerkennung von Studienleistungen und Modulprüfungen

#### **II. Masterprüfung**

- § 17 Umfang und Art der Masterprüfung
- § 18 Leistungsnachweise für die Masterprüfung
- § 19 Bestehen der Masterprüfung, Bildung der Gesamtnote
- § 20 Masterzeugnis, Masterurkunde, Transcript of Records und Diploma Supplement

#### **III. Schlussbestimmungen**

- § 21 Bescheid über Nicht-Bestehen, Bescheinigung von Prüfungsleistungen
- § 22 Ungültigkeit der Masterprüfung, Entziehung des Mastergrades
- § 23 Einsicht in die Prüfungsakten
- § 24 In-Kraft-Treten

In dieser Satzung wurde nur die weibliche Sprachform gewählt. Alle personenbezogenen Aussagen gelten jedoch stets für Frauen und Männer gleichermaßen.

Die Universität Karlsruhe (TH) hat sich im Rahmen der Umsetzung des Bolognaprozesses zum Aufbau eines Europäischen Hochschulraumes zum Ziel gesetzt, dass am Abschluss der Studierendenausbildung an der Universität Karlsruhe (TH) in der Regel der Mastergrad steht. Die Universität Karlsruhe (TH) sieht daher die an der Universität Karlsruhe (TH) angebotenen konsekutiven Bachelor- und Masterstudiengänge als Gesamtkonzept mit konsekutivem Curriculum.

## I. Allgemeine Bestimmungen

### § 1 Geltungsbereich, Ziele

(1) Diese Masterprüfungsordnung regelt Studienablauf, Prüfungen und den Abschluss des Studiums im Masterstudiengang Maschinenbau an der Universität Karlsruhe (TH).

(2) Im Masterstudium sollen die im Bachelorstudium erworbenen wissenschaftlichen Qualifikationen weiter vertieft oder ergänzt werden. Die Studentin soll in der Lage sein, die wissenschaftlichen Erkenntnisse und Methoden selbstständig anzuwenden und ihre Bedeutung und Reichweite für die Lösung komplexer wissenschaftlicher und gesellschaftlicher Problemstellungen zu bewerten.

### § 2 Akademischer Grad

Aufgrund der bestandenen Masterprüfung wird der akademische Grad „Master of Science“ (abgekürzt: „M.Sc.“) verliehen.

### § 3 Regelstudienzeit, Studienaufbau, Leistungspunkte

(1) Die Regelstudienzeit beträgt vier Semester. Sie umfasst Prüfungen, ein Berufspraktikum und die Masterarbeit.

(2) Die im Studium zu absolvierenden Lehrinhalte sind in Module gegliedert, die jeweils aus einer Lehrveranstaltung oder mehreren, thematisch und zeitlich aufeinander bezogenen Lehrveranstaltungen bestehen. Art, Umfang und Zuordnung der Lehrveranstaltungen zu einem Modul sowie die Möglichkeiten, Teilmodule untereinander zu kombinieren, beschreibt der Studienplan. Die Module und ihr Umfang werden in § 17 definiert.

(3) Der für das Absolvieren von Lehrveranstaltungen und Modulen vorgesehene Arbeitsaufwand wird in Leistungspunkten (Credits) ausgewiesen. Die Maßstäbe für die Zuordnung von Leistungspunkten entsprechen dem ECTS (European Credit Transfer System). Ein Leistungspunkt entspricht einem Arbeitsaufwand von etwa 30 Stunden.

(4) Der Umfang der für den erfolgreichen Abschluss des Studiums erforderlichen Studienleistungen wird in Leistungspunkten gemessen und beträgt insgesamt 120 Leistungspunkte.

(5) Die Verteilung der Leistungspunkte im Studienplan auf die Semester hat in der Regel gleichmäßig zu erfolgen.

(6) Lehrveranstaltungen können auch in englischer Sprache angeboten werden.

#### § 4 Aufbau der Prüfungen

(1) Die Masterprüfung besteht aus einer Masterarbeit und Modulprüfungen, jede der Modulprüfungen aus einer oder mehreren Modulteilprüfungen. Eine Modulteilprüfung besteht aus mindestens einer Erfolgskontrolle.

(2) Erfolgskontrollen sind:

1. schriftliche Prüfungen,
2. mündliche Prüfungen oder
3. Erfolgskontrollen anderer Art.

Erfolgskontrollen anderer Art sind z.B. Vorträge, Marktstudien, Projekte, Fallstudien, Experimente, schriftliche Arbeiten, Berichte, Seminararbeiten und Klausuren, sofern sie nicht als schriftliche oder mündliche Prüfung in der Modul- oder Lehrveranstaltungsbeschreibung im Studienplan ausgewiesen sind.

(3) In der Regel sind mindestens 50 % einer Modulprüfung in Form von schriftlichen oder mündlichen Prüfungen (Abs. 2, Nr. 1 und 2) abzulegen, die restlichen Prüfungen erfolgen durch Erfolgskontrollen anderer Art (Abs. 2, Nr. 3).

#### § 5 Anmeldung und Zulassung zu den Prüfungen

(1) Um zu schriftlichen und mündlichen Modulteilprüfungen (§ 4 Abs. 2, Nr. 1 und 2) in einem bestimmten Modul zugelassen zu werden, muss die Studentin vor der ersten schriftlichen oder mündlichen Modulteilprüfung in diesem Modul beim Studienbüro eine bindende Erklärung über die Wahl des betreffenden Moduls bzw. der Lehrveranstaltungen, wenn diese Wahlmöglichkeit besteht, abgeben. Darüber hinaus muss sich die Studentin für jede einzelne Modulteilprüfung, die in Form einer schriftlichen oder mündlichen Prüfung (§ 4 Abs. 2, Nr. 1 und 2) durchgeführt wird, beim Studienbüro anmelden. Dies gilt auch für die Zulassung zur Masterarbeit.

(2) Um an den Modulprüfungen teilnehmen zu können, muss sich die Studentin schriftlich oder per Online-Anmeldung beim Studienbüro anmelden. Hierbei sind die gemäß dem Studienplan für die jeweilige Modulprüfung notwendigen Studienleistungen nachzuweisen.

(3) Die Zulassung darf nur abgelehnt werden, wenn

1. die Studentin in einem mit dem Maschinenbau vergleichbaren oder einem verwandten Studiengang bereits eine Diplomvorprüfung, Diplomprüfung, Bachelor- oder Masterprüfung endgültig nicht bestanden hat, sich in einem Prüfungsverfahren befindet oder den Prüfungsanspruch in einem solchen Studiengang verloren hat,
2. die gemäß dem Studienplan für die jeweilige Modulprüfung notwendigen Studienleistungen nicht nachgewiesen werden können,
3. die in § 18 genannte Voraussetzung nicht erfüllt ist.

In Zweifelsfällen entscheidet die Prüfungskommission.

(4) Die Anmeldung zu einer ersten schriftlichen Modulprüfung gilt zugleich als bedingte Anmeldung für die Wiederholung der Modulprüfung bei nicht bestandener Prüfung.

#### § 6 Durchführung von Prüfungen und Erfolgskontrollen

(1) Erfolgskontrollen werden studienbegleitend, in der Regel im Verlauf der Vermittlung der Lehrinhalte der einzelnen Module oder zeitnah danach, durchgeführt.

(2) Die Art der Erfolgskontrolle (§ 4 Abs. 2, Nr. 1 bis 3) der einzelnen Lehrveranstaltungen wird von der Prüferin der betreffenden Lehrveranstaltung in Bezug auf die Lehrinhalte der Lehrveranstaltung und die Lehrziele des Moduls festgelegt. Die Prüferin, die Art der Erfolgskontrollen, ihre Häufigkeit, Reihenfolge und Gewichtung, die Bildung der Lehrveranstaltungsnote und der Modulnote müssen mindestens sechs Wochen vor Semesterbeginn bekannt gegeben werden. Im

Einvernehmen zwischen Prüferin und Studentin kann die Art der Erfolgskontrolle auch nachträglich geändert werden. Dabei ist jedoch § 4 Abs. 3 zu berücksichtigen.

**(3)** Eine schriftlich durchzuführende Prüfung kann auch mündlich, eine mündlich durchzuführende Prüfung kann auch schriftlich abgenommen werden. Diese Änderung muss mindestens sechs Wochen vor der Prüfung bekannt gegeben werden.

**(4)** Weist eine Studentin nach, dass sie wegen länger andauernder oder ständiger körperlicher Behinderung nicht in der Lage ist, die Erfolgskontrollen ganz oder teilweise in der vorgeschriebenen Form abzulegen, kann die zuständige Prüfungskommission – in dringenden Angelegenheiten, deren Erledigung nicht bis zu einer Sitzung der Kommission aufgeschoben werden kann, deren Vorsitzende – gestatten, Erfolgskontrollen in einer anderen Form zu erbringen.

**(5)** Bei Lehrveranstaltungen in englischer Sprache können mit Zustimmung der Studentin die entsprechenden Erfolgskontrollen in englischer Sprache abgenommen werden.

**(6)** Schriftliche Prüfungen (§ 4 Abs. 2, Nr. 1) sind in der Regel von einer Prüferin nach § 15 Abs. 2 oder § 15 Abs. 3 zu bewerten. Die Note ergibt sich aus dem arithmetischen Mittel der Einzelbewertungen. Entspricht das arithmetische Mittel keiner der in § 7 Abs. 2, Satz 2 definierten Notenstufen, so ist auf die nächstliegende Notenstufe zu runden. Bei gleichem Abstand ist auf die nächstbessere Notenstufe zu runden. Das Bewertungsverfahren soll sechs Wochen nicht überschreiten. Schriftliche Einzelprüfungen dauern mindestens 60 und höchstens 240 Minuten.

**(7)** Mündliche Prüfungen (§ 4 Abs. 2, Nr. 2) sind von mehreren Prüferinnen (Kollegialprüfung) oder von einer Prüferin in Gegenwart einer Beisitzenden als Gruppen- oder Einzelprüfungen abzunehmen und zu bewerten. Vor der Festsetzung der Note hört die Prüferin die anderen an der Kollegialprüfung mitwirkenden Prüferinnen an. Mündliche Prüfungen dauern in der Regel mindestens 15 Minuten und maximal 60 Minuten pro Studentin.

**(8)** Die wesentlichen Gegenstände und Ergebnisse der mündlichen Prüfung in den einzelnen Fächern sind in einem Protokoll festzuhalten. Das Ergebnis der Prüfung ist der Studentin im Anschluss an die mündliche Prüfung bekannt zu geben.

**(9)** Bei Prüfungen nach § 4 Abs. 2, Nr. 1 und Nr. 2 kann von der Prüferin ein Bonus von bis zu maximal 0.4 Notenpunkten für vorlesungsbegleitende Übungen oder Projektarbeiten des Pflichtbereichs, die mit der Note 1.0 bewertet werden, vergeben werden. Die Note wird in diesem Falle um den gewährten Bonus verbessert. Entspricht das so entstandene Ergebnis keiner der in § 7 Abs. 2, Satz 2 definierten Notenstufen, so ist auf die nächstliegende Notenstufe zu runden.

**(10)** Studentinnen, die sich in einem späteren Prüfungszeitraum der gleichen Prüfung unterziehen wollen, werden entsprechend den räumlichen Verhältnissen als Zuhörerinnen bei mündlichen Prüfungen zugelassen. Die Zulassung erstreckt sich nicht auf die Beratung und Bekanntgabe der Prüfungsergebnisse. Aus wichtigen Gründen oder auf Antrag der zu prüfenden Studentin ist die Zulassung zu versagen.

**(11)** Für Erfolgskontrollen anderer Art sind angemessene Bearbeitungsfristen einzuräumen und Abgabetermine festzulegen. Dabei ist durch die Art der Aufgabenstellung und durch entsprechende Dokumentation sicherzustellen, dass die erbrachte Studienleistung der Studentin zurechenbar ist. Die wesentlichen Gegenstände und Ergebnisse einer solchen Erfolgskontrolle sind in einem Protokoll festzuhalten.

**(12)** Schriftliche Arbeiten im Rahmen einer Erfolgskontrolle anderer Art haben dabei die folgende Erklärung zu tragen: „Ich versichere wahrheitsgemäß, die Arbeit selbstständig angefertigt, alle benutzten Hilfsmittel vollständig und genau angegeben und alles kenntlich gemacht zu haben, was aus Arbeiten anderer unverändert oder mit Abänderungen entnommen wurde.“ Trägt die Arbeit diese Erklärung nicht, wird diese Arbeit nicht angenommen. Die wesentlichen Gegenstände und Ergebnisse einer solchen Erfolgskontrolle sind in einem Protokoll festzuhalten.

**(13)** Bei mündlich durchgeführten Erfolgskontrollen anderer Art muss neben der Prüferin eine Beisitzende anwesend sein, die zusätzlich zur Prüferin die Protokolle zeichnet.

### § 7 Bewertung von Prüfungen und Erfolgskontrollen

**(1)** Das Ergebnis einer Erfolgskontrolle wird von den jeweiligen Prüferinnen in Form einer Note festgesetzt.

**(2)** Im Masterzeugnis dürfen nur folgende Noten verwendet werden:

|   |   |                             |   |   |
|---|---|-----------------------------|---|---|
| 1 | = | sehr gut (very good)        | = | hervorragende Leistung,   |
| 2 | = | gut (good)                  | = | eine Leistung, die erheblich über den durchschnittlichen Anforderungen liegt, |
| 3 | = | befriedigend (satisfactory) | = | eine Leistung, die durchschnittlichen Anforderungen entspricht,               |
| 4 | = | ausreichend (sufficient)    | = | eine Leistung, die trotz ihrer Mängel noch den Anforderungen genügt,          |
| 5 | = | nicht ausreichend (failed)  | = | eine Leistung, die wegen erheblicher Mängel nicht den Anforderungen genügt.   |

Für die Masterarbeit und die Modulteilprüfungen sind zur differenzierten Bewertung nur folgende Noten zugelassen:

|   |   |               |   |                   |
|---|---|---------------|---|-------------------|
| 1 | : | 1.0, 1.3      | = | sehr gut          |
| 2 | : | 1.7, 2.0, 2.3 | = | gut               |
| 3 | : | 2.7, 3.0, 3.3 | = | befriedigend      |
| 4 | : | 3.7, 4.0      | = | ausreichend       |
| 5 | : | 4.7, 5.0      | = | nicht ausreichend |

Diese Noten müssen in den Protokollen und in den Anlagen (Transcript of Records und Diploma Supplement) verwendet werden.

**(3)** Für Erfolgskontrollen anderer Art kann im Studienplan die Benotung mit „bestanden“ (passed) oder „nicht bestanden“ (failed) vorgesehen werden.

**(4)** Bei der Bildung der gewichteten Durchschnitte der Modulnoten und der Gesamtnote wird nur die erste Dezimalstelle hinter dem Komma berücksichtigt; alle weiteren Stellen werden ohne Rundung gestrichen.

**(5)** Jedes Modul, jede Lehrveranstaltung und jede Erfolgskontrolle darf in demselben Studiengang nur einmal angerechnet werden. Die Anrechnung eines Moduls, einer Lehrveranstaltung oder einer Erfolgskontrolle ist darüber hinaus ausgeschlossen, wenn das betreffende Modul, die Lehrveranstaltung oder die Erfolgskontrolle bereits in einem grundständigen Bachelorstudiengang angerechnet wurde, auf dem dieser Masterstudiengang konsekutiv aufbaut.

**(6)** Erfolgskontrollen anderer Art dürfen in Modulteilprüfungen oder Modulprüfungen nur eingerechnet werden, wenn die Benotung nicht nach Absatz 3 erfolgt ist. Die zu dokumentierenden Erfolgskontrollen und die daran geknüpften Bedingungen werden im Studienplan festgelegt.

**(7)** Eine Modulteilprüfung ist bestanden, wenn die Note mindestens „ausreichend“ (4.0) ist.

**(8)** Eine Modulprüfung ist dann bestanden, wenn die Modulnote mindestens „ausreichend“ (4.0) ist. Die Modulprüfung und die Bildung der Modulnote werden im Studienplan geregelt. Die differenzierten Lehrveranstaltungsnoten (Absatz 2) sind bei der Berechnung der Modulnoten als Ausgangsdaten zu verwenden.

**(9)** Enthält der Studienplan keine Regelung darüber, wann eine Modulprüfung bestanden ist, so ist diese Modulprüfung dann endgültig nicht bestanden, wenn eine dem Modul zugeordnete Modulteilprüfung endgültig nicht bestanden wurde.

**(10)** Die Ergebnisse der Masterarbeit, der Modulprüfungen bzw. der Modulteilprüfungen, der Erfolgskontrollen anderer Art sowie die erworbenen Leistungspunkte werden durch das Studienbüro der Universität erfasst.

**(11)** Die Noten der Teilmodule eines Moduls gehen in die Modulnote mit einem Gewicht proportional zu den ausgewiesenen Leistungspunkten der Module ein.

**(12)** Innerhalb der Regelstudienzeit, einschließlich der Urlaubssemester für das Studium an einer ausländischen Hochschule (Regelprüfungszeit), können in einem Modul auch mehr Leistungspunkte erworben werden als für das Bestehen der Modulprüfung erforderlich sind. Bei der Festlegung der Modulnote werden dabei alle Teilmodule gemäß ihrer Leistungspunkte gewichtet.

**(13)** Die Gesamtnote der Masterprüfung, die Modulnoten und die Modulteilnoten lauten:

|     |             |   |              |
|-----|-------------|---|--------------|
|     | bis 1.5     | = | sehr gut     |
| von | 1.6 bis 2.5 | = | gut          |
| von | 2.6 bis 3.5 | = | befriedigend |
| von | 3.6 bis 4.0 | = | ausreichend  |

**(14)** Zusätzlich zu den Noten nach Absatz 2 werden ECTS-Noten für Modulteilprüfungen, Modulprüfungen und für die Masterprüfung nach folgender Skala vergeben:

| ECTS-Note | Definition mit Quote  |
|-----------|---|
| A         | gehört zu den besten 10 % der Studentinnen, die die Erfolgskontrolle bestanden haben,                         |
| B         | gehört zu den nächsten 25 % der Studentinnen, die die Erfolgskontrolle bestanden haben,                       |
| C         | gehört zu den nächsten 30 % der Studentinnen, die die Erfolgskontrolle bestanden haben,                       |
| D         | gehört zu den nächsten 25 % der Studentinnen, die die Erfolgskontrolle bestanden haben,                       |
| E         | gehört zu den letzten 10 % der Studentinnen, die die Erfolgskontrolle bestanden haben,                        |
| FX        | <i>nicht bestanden</i> (failed) - es sind Verbesserungen erforderlich, bevor die Leistungen anerkannt werden, |
| F         | <i>nicht bestanden</i> (failed) - es sind erhebliche Verbesserungen erforderlich.                             |

Die Quote ist als der Prozentsatz der erfolgreichen Studentinnen definiert, die diese Note in der Regel erhalten. Dabei ist von einer mindestens fünfjährigen Datenbasis über mindestens 30 Studentinnen auszugehen. Für die Ermittlung der Notenverteilungen, die für die ECTS-Noten erforderlich sind, ist das Studienbüro der Universität zuständig.

### § 8 Erlöschen des Prüfungsanspruchs, Wiederholung von Prüfungen und Erfolgskontrollen

**(1)** Studentinnen können eine nicht bestandene mündliche Prüfung (§ 4 Abs. 2, Nr. 2) einmal wiederholen.

**(2)** Studentinnen können eine nicht bestandene schriftliche Prüfung (§ 4 Abs. 2, Nr. 1) einmal wiederholen. Wird eine schriftliche Wiederholungsprüfung mit „nicht ausreichend“ bewertet, so findet eine mündliche Nachprüfung im zeitlichen Zusammenhang mit dem Termin der nicht bestandenen Prüfung statt. In diesem Falle kann die Note dieser Prüfung nicht besser als „ausreichend“ (4.0) sein.

**(3)** Wiederholungsprüfungen nach Absatz 1 und 2 müssen in Inhalt, Umfang und Form (mündlich oder schriftlich) der ersten entsprechen. Ausnahmen kann die zuständige Prüfungskommission auf Antrag zulassen. Fehlversuche an anderen Hochschulen sind anzurechnen.

**(4)** Die Wiederholung einer Erfolgskontrolle anderer Art (§ 4 Abs. 2, Nr. 3) wird im Studienplan geregelt.

**(5)** Eine zweite Wiederholung derselben schriftlichen oder mündlichen Prüfung ist nur in Ausnahmefällen zulässig. Einen Antrag auf Zweitwiederholung hat die Studentin schriftlich bei der Prüfungskommission zu stellen. Über den ersten Antrag einer Studentin auf Zweitwiederholung entscheidet die Prüfungskommission, wenn sie den Antrag genehmigt. Wenn die Prüfungskommission diesen Antrag ablehnt, entscheidet die Rektorin. Über weitere Anträge auf Zweitwiederholung entscheidet nach Stellungnahme der Prüfungskommission die Rektorin. Absatz 2, Satz 2 und 3 gilt entsprechend.

**(6)** Die Wiederholung einer bestandenen Erfolgskontrolle ist nicht zulässig.

**(7)** Eine Modulprüfung ist endgültig nicht bestanden, wenn mindestens ein Teilmodul des Moduls endgültig nicht bestanden ist.

**(8)** Die Masterarbeit kann bei einer Bewertung mit „nicht ausreichend“ einmal wiederholt werden. Eine zweite Wiederholung der Masterarbeit ist ausgeschlossen.

**(9)** Ist gemäß § 34 Abs. 2, Satz 3 LHG die Masterprüfung bis zum Beginn der Vorlesungszeit des achten Fachsemesters einschließlich etwaiger Wiederholungen nicht vollständig abgelegt, so erlischt der Prüfungsanspruch im Studiengang Maschinenbau, es sei denn, dass die Studentin die Fristüberschreitung nicht zu vertreten hat. Die Entscheidung darüber trifft die Prüfungskommission.

### **§ 9 Versäumnis, Rücktritt, Täuschung, Ordnungsverstoß**

**(1)** Die Studentin kann bei schriftlichen Modulprüfungen ohne Angabe von Gründen bis zur Ausgabe der Prüfungsaufgaben zurücktreten. Bei mündlichen Modulprüfungen muss der Rücktritt spätestens drei Werktage vor dem betreffenden Prüfungstermin erklärt werden. Die Abmeldung kann schriftlich bei der Prüferin oder per Online-Abmeldung beim Studienbüro erfolgen.

**(2)** Eine Modulprüfung gilt als mit „nicht ausreichend“ bewertet, wenn die Studentin einen Prüfungstermin ohne triftigen Grund versäumt oder wenn sie nach Beginn der Prüfung ohne triftigen Grund von der Prüfung zurücktritt. Dasselbe gilt, wenn die Masterarbeit nicht innerhalb der vorgesehenen Bearbeitungszeit erbracht wird, es sei denn, die Studentin hat die Fristüberschreitung nicht zu vertreten.

**(3)** Der für den Rücktritt nach Beginn der Prüfung oder das Versäumnis geltend gemachte Grund muss der Prüfungskommission unverzüglich schriftlich angezeigt und glaubhaft gemacht werden. Bei Krankheit der Studentin bzw. eines von ihr allein zu versorgenden Kindes oder pflegebedürftigen Angehörigen kann die Vorlage eines ärztlichen Attestes und in Zweifelsfällen ein amtsärztliches Attest verlangt werden. Die Anerkennung des Rücktritts ist ausgeschlossen, wenn bis zum Eintritt des Hinderungsgrundes bereits Prüfungsleistungen erbracht worden sind und nach deren Ergebnis die Prüfung nicht bestanden werden kann. Wird der Grund anerkannt, wird ein neuer Termin anberaumt. Die bereits vorliegenden Prüfungsergebnisse sind in diesem Fall anzurechnen.

**(4)** Versucht die Studentin das Ergebnis seiner Modulprüfung durch Täuschung oder Benutzung nicht zugelassener Hilfsmittel zu beeinflussen, gilt die betreffende Modulprüfung als mit „nicht ausreichend“ (5.0) bewertet. Bei Modulprüfungen, die aus mehreren Teilprüfungen bestehen, werden die Prüfungsleistungen dieses Moduls, die bis zu einem anerkannten Rücktritt bzw. einem anerkannten Versäumnis einer Prüfungsleistung dieses Moduls erbracht worden sind, angerechnet.

**(5)** Eine Studentin, die den ordnungsgemäßen Ablauf der Prüfung stört, kann von der jeweiligen Prüferin oder Aufsicht Führenden von der Fortsetzung der Modulprüfung ausgeschlossen werden.

In diesem Fall gilt die betreffende Prüfungsleistung als mit „nicht ausreichend“ (5.0) bewertet. In schwerwiegenden Fällen kann die Prüfungskommission die Studentin von der Erbringung weiterer Prüfungsleistungen ausschließen.

**(6)** Die Studentin kann innerhalb einer Frist von einem Monat verlangen, dass Entscheidungen gemäß Absatz 4 und 5 von der Prüfungskommission überprüft werden. Belastende Entscheidungen der Prüfungskommission sind der Studentin unverzüglich schriftlich mitzuteilen. Sie sind zu begründen und mit einer Rechtsbehelfsbelehrung zu versehen. Der Studentin ist vor einer Entscheidung Gelegenheit zur Äußerung zu geben.

**(7)** Näheres regelt die Allgemeine Satzung der Universität Karlsruhe (TH) zur Redlichkeit bei Prüfungen und Praktika („Verhaltensordnung“).

### § 10 Mutterschutz, Elternzeit

**(1)** Auf Antrag einer Studentin sind die Mutterschutzfristen, wie sie im jeweils gültigen Gesetz zum Schutz der erwerbstätigen Mutter (MuSchG) festgelegt sind, entsprechend zu berücksichtigen. Dem Antrag sind die erforderlichen Nachweise beizufügen. Die Mutterschutzfristen unterbrechen jede Frist nach dieser Prüfungsordnung. Die Dauer des Mutterschutzes wird nicht in die Frist eingerechnet.

**(2)** Gleichfalls sind die Fristen der Elternzeit nach Maßgabe des jeweiligen gültigen Gesetzes (BErzGG) auf Antrag zu berücksichtigen. Die Studentin muss bis spätestens vier Wochen vor dem Zeitpunkt, von dem an sie die Elternzeit antreten will, der Prüfungskommission unter Beifügung der erforderlichen Nachweise schriftlich mitteilen, in welchem Zeitraum sie die Elternzeit in Anspruch nehmen will. Die Prüfungskommission hat zu prüfen, ob die gesetzlichen Voraussetzungen vorliegen, die bei einer Arbeitnehmerin den Anspruch auf Elternzeit auslösen würden, und teilt der Studentin das Ergebnis sowie die neu festgesetzten Prüfungszeiten unverzüglich mit. Die Bearbeitungszeit der Masterarbeit kann nicht durch eine Elternzeit unterbrochen werden. Die gestellte Arbeit gilt als nicht vergeben. Nach Ablauf der Elternzeit erhält die Studentin ein neues Thema.

### § 11 Masterarbeit

**(1)** Voraussetzung für die Zulassung zur Masterarbeit ist grundsätzlich, dass die Studierende alle Modulteilprüfungen bis auf maximal ein Modul des ersten Abschnitts laut § 17 sowie das Berufspraktikum nach § 12 absolviert hat. Der Antrag auf Zulassung zur Masterarbeit ist innerhalb von drei Monaten nach Ablegung der letzten Modulprüfung zu stellen. Versäumt die Studentin diese Frist ohne triftige Gründe, so gilt die Masterarbeit im ersten Versuch als mit „nicht ausreichend“ (5.0) bewertet. Im Übrigen gilt §18 entsprechend. Auf Antrag der Studentin sorgt ausnahmsweise die Vorsitzende der Prüfungskommission dafür, dass die Studentin innerhalb von vier Wochen nach Antragstellung von einer Betreuerin ein Thema für die Masterarbeit erhält. Die Ausgabe des Themas erfolgt in diesem Fall über die Vorsitzende der Prüfungskommission.

**(2)** Thema, Aufgabenstellung und Umfang der Masterarbeit sind von der Betreuerin so zu begrenzen, dass sie mit dem in Absatz 3 festgelegten Arbeitsaufwand bearbeitet werden kann.

**(3)** Die Masterarbeit soll zeigen, dass die Studentin in der Lage ist, ein Problem aus dem Maschinenbau selbstständig und in begrenzter Zeit nach wissenschaftlichen Methoden, die dem Stand der Forschung entsprechen, zu bearbeiten. Der Masterarbeit werden 20 Leistungspunkte zugeordnet. Die Bearbeitungsdauer beträgt vier Monate. Im Anschluss an die Masterarbeit, spätestens vier Wochen nach Abgabe, findet am Institut der Prüferin ein Kolloquium von etwa 30 Minuten Dauer über das Thema der Masterarbeit und deren Ergebnisse statt.

**(4)** Die Masterarbeit kann von jeder Prüferin nach § 15 Abs. 2 vergeben werden. Die Prüferin muss dabei der gewählten Vertiefungsrichtung zugeordnet sein. Die Zuordnung der Institute zu den jeweiligen Vertiefungsrichtungen findet sich im Studienplan. Soll die Masterarbeit außerhalb der Fakultät für Maschinenbau angefertigt werden, so bedarf dies der Genehmigung der Prüfungskommission. Der Studentin ist Gelegenheit zu geben, für das Thema Vorschläge zu machen.

Die Masterarbeit kann auch in Form einer Gruppenarbeit zugelassen werden, wenn der als Prüfungsleistung zu bewertende Beitrag der einzelnen Studentin aufgrund objektiver Kriterien, die eine eindeutige Abgrenzung ermöglichen, deutlich unterscheidbar ist und die Anforderung nach Absatz 3 erfüllt. Die Masterarbeit kann im Einvernehmen mit den Prüferinnen auch auf Englisch oder Französisch geschrieben werden.

**(5)** Bei der Abgabe der Masterarbeit hat die Studentin schriftlich zu versichern, dass sie die Arbeit selbstständig verfasst hat und keine anderen als die von ihr angegebenen Quellen und Hilfsmittel benutzt hat, die wörtlich oder inhaltlich übernommenen Stellen als solche kenntlich gemacht und die Satzung der Universität Karlsruhe (TH) zur Sicherung guter wissenschaftlicher Praxis in der jeweils gültigen Fassung beachtet hat. Wenn diese Erklärung nicht enthalten ist, wird die Arbeit nicht angenommen. Bei Abgabe einer unwahren Versicherung wird die Masterarbeit mit „nicht ausreichend“ (5.0) bewertet.

**(6)** Der Zeitpunkt der Ausgabe des Themas der Masterarbeit und der Zeitpunkt der Abgabe der Masterarbeit sind aktenkundig zu machen. Die Studentin kann das Thema der Masterarbeit nur einmal und nur innerhalb der ersten zwei Monate der Bearbeitungszeit zurückgeben. Auf begründeten Antrag der Studentin kann die Prüfungskommission die in Absatz 3 festgelegte Bearbeitungszeit um höchstens zwei Monate verlängern. Wird die Masterarbeit nicht fristgerecht abgeliefert, gilt sie als mit „nicht ausreichend“ bewertet, es sei denn, dass die Studentin dieses Versäumnis nicht zu vertreten hat. § 7 und § 8 gelten entsprechend.

**(7)** Die Masterarbeit wird von einer Betreuerin sowie in der Regel von einer weiteren Prüferin aus der Fakultät für Maschinenbau begutachtet und bewertet. Eine der beiden muss Juniorprofessorin oder Professorin sein. Bei nicht übereinstimmender Beurteilung der beiden Prüferinnen setzt die Prüfungskommission im Rahmen der Bewertung der beiden Prüferinnen die Note der Masterarbeit fest. Der Bewertungszeitraum soll sechs Wochen nicht überschreiten.

## **§ 12 Berufspraktikum**

**(1)** Während des Masterstudiums ist ein mindestens sechswöchiges Berufspraktikum abzuleisten, welches geeignet ist, der Studentin eine Anschauung von berufspraktischer Tätigkeit im Maschinenbau zu vermitteln. Dem Berufspraktikum sind 8 Leistungspunkte zugeordnet.

**(2)** Die Studentin setzt sich in eigener Verantwortung mit geeigneten privaten bzw. öffentlichen Einrichtungen in Verbindung, an denen das Praktikum abgeleistet werden kann. Die Studentin wird dabei von einer Prüferin nach § 15 Abs. 2 und einer Firmenbetreuerin betreut.

**(3)** Bei der Anmeldung zum zweiten Abschnitt der Masterprüfung muss das komplette Berufspraktikum anerkannt sein.

**(4)** Weitere Regelungen zu Inhalt, Durchführung und Anerkennung des Berufspraktikums finden sich im Studienplan. Das Berufspraktikum geht nicht in die Gesamtnote ein.

## **§ 13 Zusatzmodule, Zusatzleistungen**

**(1)** Die Studentin kann sich weiteren Prüfungen im Umfang von höchstens 20 Leistungspunkten unterziehen. § 3 und § 4 der Prüfungsordnung bleiben davon unberührt.

**(2)** Das Ergebnis maximal zweier Module, die jeweils mindestens 3 Leistungspunkte umfassen müssen, wird auf Antrag der Studentin in das Masterzeugnis aufgenommen und als Zusatzmodul gekennzeichnet. Zusatzmodule werden bei der Festsetzung der Gesamtnote nicht mit einbezogen. Alle Zusatzleistungen werden im Transcript of Records automatisch aufgenommen und als Zusatzleistungen gekennzeichnet. Zusatzleistungen werden mit den nach § 7 vorgesehenen Noten gelistet. Diese Zusatzleistungen gehen nicht in die Festsetzung der Gesamt- und Modulnoten ein.

**(3)** Die Studentin hat bereits bei der Anmeldung zu einer Modulteilprüfung in einem Modul diese als Zusatzleistung zu deklarieren.

### § 14 Prüfungskommission

(1) Für den Masterstudiengang im Maschinenbau wird eine Prüfungskommission gebildet. Sie besteht aus vier stimmberechtigten Mitgliedern: zwei Professorinnen, Juniorprofessorinnen, Hochschul- oder Privatdozentinnen, zwei Vertreterinnen der Gruppe der wissenschaftlichen Mitarbeiterinnen nach § 10 Abs. 1, Satz 2, Nr. 2 LHG und einer Vertreterin der Studentinnen mit beratender Stimme. Die Amtszeit der nichtstudentischen Mitglieder beträgt zwei Jahre, die des studentischen Mitglieds ein Jahr.

(2) Die Vorsitzende, ihre Stellvertreterin, die weiteren Mitglieder der Prüfungskommission sowie deren Stellvertreterinnen werden vom Fakultätsrat bestellt, die Mitglieder der Gruppe der wissenschaftlichen Mitarbeiterinnen nach § 10 Abs. 1, Satz 2, Nr. 2 LHG und die Vertreterin der Studentinnen auf Vorschlag der Mitglieder der jeweiligen Gruppe; Wiederbestellung ist möglich. Die Vorsitzende und deren Stellvertreterin müssen Professorin oder Juniorprofessorin sein. Die Vorsitzende der Prüfungskommission nimmt die laufenden Geschäfte wahr und wird durch die Prüfungssekretariate unterstützt.

(3) Die Prüfungskommission ist zuständig für die Durchführung der ihr durch diese Studien- und Prüfungsordnung zugewiesenen Aufgaben. Sie achtet auf die Einhaltung der Bestimmungen dieser Studien- und Prüfungsordnung und fällt die Entscheidung in Prüfungsangelegenheiten. Sie entscheidet über die Anrechnung von Studienzeiten, Studienleistungen und Modulprüfungen und übernimmt die Gleichwertigkeitsfeststellung. Sie berichtet der jeweiligen Fakultät regelmäßig über die Entwicklung der Prüfungs- und Studienzeiten, einschließlich der Bearbeitungszeiten für die Masterarbeiten und die Verteilung der Modul- und Gesamtnoten. Sie ist zuständig für Anregungen zur Reform der Studien- und Prüfungsordnung und zu Modulbeschreibungen.

(4) Die Prüfungskommission kann die Erledigung ihrer Aufgaben für alle Regelfälle auf die Vorsitzende der Prüfungskommission übertragen.

(5) Die Mitglieder der Prüfungskommission haben das Recht, der Abnahme von Prüfungen bei-zuwohnen. Die Mitglieder der Prüfungskommission, die Prüferinnen und die Beisitzenden unterliegen der Amtsverschwiegenheit. Sofern sie nicht im öffentlichen Dienst stehen, sind sie durch die Vorsitzende zur Verschwiegenheit zu verpflichten.

(6) In Angelegenheiten der Prüfungskommission, die eine an einer anderen Fakultät zu absolvierende Prüfungsleistung betreffen, ist auf Antrag eines Mitgliedes der Prüfungskommission eine fachlich zuständige und von der betroffenen Fakultät zu nennende Professorin, Juniorprofessorin, Hochschul- oder Privatdozentin hinzuziehen. Sie hat in diesem Punkt Stimmrecht.

(7) Belastende Entscheidungen der Prüfungskommission sind der Studentin schriftlich mitzuteilen. Sie sind zu begründen und mit einer Rechtsbehelfsbelehrung zu versehen. Widersprüche gegen Entscheidungen der Prüfungskommission sind innerhalb eines Monats nach Zugang der Entscheidung schriftlich oder zur Niederschrift an die Prüfungskommission zu richten. Hilft die Prüfungskommission dem Widerspruch nicht ab, ist er zur Entscheidung dem für die Lehre zuständigen Mitglied des Rektorats vorzulegen.

### § 15 Prüferinnen und Beisitzende

(1) Die Prüfungskommission bestellt die Prüferinnen und die Beisitzenden. Sie kann die Bestellung der Vorsitzenden übertragen.

(2) Prüferinnen sind Hochschullehrerinnen und habilitierte Mitglieder sowie wissenschaftliche Mitarbeiterinnen der Fakultät für Maschinenbau, denen die Prüfungsbefugnis übertragen wurde. Zur Prüferin und Beisitzenden darf nur bestellt werden, wer mindestens die dem jeweiligen Prüfungsgegenstand entsprechende fachwissenschaftliche Qualifikation erworben hat. Bei der Bewertung der Masterarbeit muss eine Prüferin Hochschullehrerin sein.

(3) Soweit Lehrveranstaltungen von anderen als den unter Absatz 2 genannten Personen durchgeführt werden, sollen diese zur Prüferin bestellt werden, wenn die jeweilige Fakultät ihr eine diesbezügliche Prüfungsbefugnis erteilt hat.

**(4)** Zur Beisitzenden darf nur bestellt werden, wer einen Diplom- oder Masterabschluss in einem Studiengang der Fakultät für Maschinenbau oder einen gleichwertigen akademischen Abschluss erworben hat.

### **§ 16 Anrechnung von Studienzeiten, Anerkennung von Studienleistungen und Modulprüfungen**

**(1)** Studienzeiten und gleichwertige Studienleistungen, Modulprüfungen und Modulteilprüfungen, die in gleichen oder anderen Studiengängen an anderen Hochschulen erbracht wurden, werden von Amts wegen angerechnet. Gleichwertigkeit ist festzustellen, wenn Leistungen in Inhalt, Umfang und in den Anforderungen denjenigen des Studiengangs im Wesentlichen entsprechen. Dabei ist kein schematischer Vergleich, sondern eine Gesamtbetrachtung vorzunehmen. Bezüglich des Umfangs einer zur Anerkennung vorgelegten Studienleistung und Modulprüfung werden die Grundsätze des ECTS herangezogen; die inhaltliche Gleichwertigkeitsprüfung orientiert sich an den Qualifikationszielen des Moduls.

**(2)** Werden Leistungen angerechnet, können die Noten – soweit die Notensysteme vergleichbar sind – übernommen werden und in die Berechnung der Modulnoten und der Gesamtnote einbezogen werden. Die Anerkennung wird im Zeugnis gekennzeichnet. Bei unvergleichbaren Notensystemen wird nur der Vermerk „anerkannt“ aufgenommen. Die Studentin hat die für die Anrechnung erforderlichen Unterlagen vorzulegen.

**(3)** Bei der Anrechnung von Studienzeiten und der Anerkennung von Studienleistungen, Modulprüfungen und Modulteilprüfungen, die außerhalb der Bundesrepublik erbracht wurden, sind die von der Kultusministerkonferenz und der Hochschulrektorenkonferenz gebilligten Äquivalenzvereinbarungen sowie Absprachen im Rahmen der Hochschulpartnerschaften zu beachten.

**(4)** Absatz 1 gilt auch für Studienzeiten, Studienleistungen, Modulprüfungen und Modulteilprüfungen, die in staatlich anerkannten Fernstudien- und an anderen Bildungseinrichtungen, insbesondere an staatlichen oder staatlich anerkannten Berufsakademien erworben wurden.

**(5)** Die Anerkennung von Teilen der Masterprüfung kann versagt werden, wenn in einem Studiengang mehr als die Hälfte aller Erfolgskontrollen und/oder in einem Studiengang mehr als die Hälfte der erforderlichen Leistungspunkte und/oder die Masterarbeit anerkannt werden soll/en. Dies gilt sowohl bei einem Studiengangwechsel als auch bei einem Studienortwechsel.

**(6)** Zuständig für die Anrechnungen ist die Prüfungskommission. Vor Feststellungen über die Gleichwertigkeit können die zuständigen Fachvertreterinnen gehört werden. Die Prüfungskommission entscheidet in Abhängigkeit von Art und Umfang der anzurechnenden Studien- und Prüfungsleistungen über die Einstufung in ein höheres Fachsemester.

## **II. Masterprüfung**

### **§ 17 Umfang und Art der Masterprüfung**

**(1)** Im Masterstudiengang Maschinenbau besteht die Möglichkeit der Wahl einer Vertiefungsrichtung. Die möglichen Vertiefungsrichtungen sind im Studienplan angegeben.

**(2)** Die Masterprüfung gliedert sich in zwei Abschnitte. Der erste Abschnitt besteht aus den Modulteilprüfungen in den Modulen nach Absatz 3 sowie dem Berufspraktikum nach § 12. Die Masterarbeit bildet den zweiten Prüfungsabschnitt.

**(3)** In den beiden Studienjahren sind die Modulteilprüfungen aus folgenden Modulen abzulegen:

1. Drei Wahlpflichtfächer: im Umfang von je 5 Leistungspunkten,
2. Mathematische Methoden: im Umfang von 6 Leistungspunkten,
3. Produktentstehung: im Umfang von 15 Leistungspunkten,
4. Modellbildung und Simulation: im Umfang von 7 Leistungspunkten,
5. Fachpraktikum: im Umfang von 3 Leistungspunkten,
6. Wahlfach: im Umfang von 4 Leistungspunkten,
7. Fachübergreifendes Wahlfach Bereich Naturwissenschaften/Informatik/Elektrotechnik: im Umfang von 6 Leistungspunkten,
8. Fachübergreifendes Wahlfach Bereich Wirtschaft/Recht: im Umfang von 4 Leistungspunkten,
9. Zwei Schwerpunkte, bestehend aus je einem Kern- und Ergänzungsmodul, wobei in jedem Schwerpunkt ein Umfang von insgesamt mindestens 16 Leistungspunkten absolviert werden muss.

Neben den in Absatz 3 genannten Modulen findet die Vermittlung von Schlüsselqualifikationen im Umfang von 6 Leistungspunkten im Rahmen der fachwissenschaftlichen Übungen und Projekte statt.

**(4)** Die den Modulen zugeordneten, wählbaren Lehrveranstaltungen und Leistungspunkte, die Erfolgskontrollen und Studienleistungen sowie die für die Schwerpunkte zur Auswahl stehenden Module sind im Studienplan festgelegt. Die Wahlmöglichkeiten richten sich dabei nach der gewählten Vertiefungsrichtung. Zu den entsprechenden Modulteilprüfungen kann nur zugelassen werden, wer die Anforderungen nach § 5 erfüllt.

**(5)** Im vierten Semester ist als eine weitere Prüfungsleistung eine Masterarbeit gemäß § 11 anzufertigen.

### **§ 18 Leistungsnachweise für die Masterprüfung**

Voraussetzung für die Anmeldung zur letzten Modulprüfung der Masterprüfung ist die Bescheinigung über das erfolgreich abgeleistete Berufspraktikum nach § 12. In Ausnahmefällen kann die Prüfungskommission die nachträgliche Vorlage dieses Leistungsnachweises genehmigen.

### **§ 19 Bestehen der Masterprüfung, Bildung der Gesamtnote**

**(1)** Die Masterprüfung ist bestanden, wenn alle in § 17 genannten Prüfungsleistungen mindestens mit „ausreichend“ bewertet wurden.

**(2)** Die Gesamtnote der Masterprüfung errechnet sich als ein mit Leistungspunkten gewichteter Notendurchschnitt.

**(3)** Hat die Studentin die Masterarbeit mit der Note 1.0 und die Masterprüfung mit einem Durchschnitt von 1.2 oder besser abgeschlossen, so wird das Prädikat „mit Auszeichnung“ (with distinction) verliehen.

### **§ 20 Masterzeugnis, Masterurkunde, Transcript of Records und Diploma Supplement**

**(1)** Über die Masterprüfung wird nach Bewertung der letzten Prüfungsleistung eine Masterurkunde und ein Zeugnis erstellt. Die Ausfertigung von Masterurkunde und Zeugnis soll nicht später als sechs Wochen nach der Bewertung der letzten Prüfungsleistung erfolgen. Masterurkunde und Masterzeugnis werden in deutscher und englischer Sprache ausgestellt. Masterurkunde und

Zeugnis tragen das Datum der erfolgreichen Erbringung der letzten Prüfungsleistung. Sie werden der Studentin gleichzeitig ausgehändigt. In der Masterurkunde wird die Verleihung des akademischen Mastergrades beurkundet. Die Masterurkunde wird von der Rektorin und der Dekanin unterzeichnet und mit dem Siegel der Universität versehen.

**(2)** Das Zeugnis enthält den Namen der gewählten Vertiefungsrichtung, die zugeordneten Modulprüfungen mit Noten und Modulteilbezeichnungen, Note und Thema der Masterarbeit, deren zugeordnete Leistungspunkte und ECTS-Noten und die Gesamtnote und die ihr entsprechende ECTS-Note. Das Zeugnis ist von den Dekaninnen der beteiligten Fakultäten und von der Vorsitzenden der Prüfungskommission zu unterzeichnen.

**(3)** Weiterhin erhält die Studentin als Anhang ein Diploma Supplement in deutscher und englischer Sprache, das den Vorgaben des jeweils gültigen ECTS User's Guide entspricht. Das Diploma Supplement enthält eine Abschrift der Studiendaten der Studentin (Transcript of Records).

**(4)** Die Abschrift der Studiendaten (Transcript of Records) enthält in strukturierter Form alle von der Studentin erbrachten Prüfungsleistungen sowie die der jeweiligen Vertiefungsrichtung zugeordneten Module mit den Modulnoten, entsprechender ECTS-Note und zugeordneten Leistungspunkten sowie die den Modulen zugeordneten Lehrveranstaltungen samt Noten und zugeordneten Leistungspunkten. Aus der Abschrift der Studiendaten soll die Zugehörigkeit von Lehrveranstaltungen zu den einzelnen Modulen deutlich erkennbar sein. Angerechnete Studienleistungen sind im Transcript of Records aufzunehmen.

**(5)** Die Masterurkunde, das Masterzeugnis und das Diploma Supplement einschließlich des Transcript of Records werden vom Studienbüro der Universität ausgestellt.

### III. Schlussbestimmungen

#### § 21 Bescheid über Nicht-Bestehen, Bescheinigung von Prüfungsleistungen

**(1)** Der Bescheid über die endgültig nicht bestandene Masterprüfung wird der Studentin in schriftlicher Form erteilt. Der Bescheid ist mit einer Rechtsbehelfsbelehrung zu versehen.

**(2)** Hat die Studentin die Masterprüfung endgültig nicht bestanden, wird ihr auf Antrag und gegen Vorlage der Exmatrikulationsbescheinigung eine schriftliche Bescheinigung ausgestellt, die die erbrachten Prüfungsleistungen und deren Noten sowie die zur Prüfung noch fehlenden Prüfungsleistungen enthält und erkennen lässt, dass die Prüfung insgesamt nicht bestanden ist. Dasselbe gilt, wenn der Prüfungsanspruch erloschen ist.

#### § 22 Ungültigkeit der Masterprüfung, Entziehung des Mastergrades

**(1)** Hat die Studentin bei einer Prüfungsleistung getäuscht und wird diese Tatsache nach der Aushändigung des Zeugnisses bekannt, so können die Noten der Modulprüfungen, bei deren Erbringung die Studentin getäuscht hat, berichtigt werden. Gegebenenfalls kann die Modulprüfung für „nicht ausreichend“ (5.0) und die Masterprüfung für „nicht bestanden“ erklärt werden.

**(2)** Waren die Voraussetzungen für die Zulassung zu einer Prüfung nicht erfüllt, ohne dass die Studentin darüber täuschen wollte, und wird diese Tatsache erst nach Aushändigung des Zeugnisses bekannt, wird dieser Mangel durch das Bestehen der Prüfung geheilt. Hat die Studentin die Zulassung vorsätzlich zu Unrecht erwirkt, so kann die Modulprüfung für „nicht ausreichend“ (5.0) und die Masterprüfung für „nicht bestanden“ erklärt werden.

**(3)** Vor einer Entscheidung der Prüfungskommission ist Gelegenheit zur Äußerung zu geben.

- (4) Das unrichtige Zeugnis ist zu entziehen und gegebenenfalls ein neues zu erteilen. Mit dem unrichtigen Zeugnis ist auch die Masterurkunde einzuziehen, wenn die Masterprüfung aufgrund einer Täuschung für „nicht bestanden“ erklärt wurde.
- (5) Eine Entscheidung nach Absatz 1 und Absatz 2, Satz 2 ist nach einer Frist von fünf Jahren ab dem Datum des Zeugnisses ausgeschlossen.
- (6) Die Aberkennung des akademischen Grades richtet sich nach den gesetzlichen Vorschriften.

### **§ 23 Einsicht in die Prüfungsakten**

- (1) Nach Abschluss der Masterprüfung wird der Studentin auf Antrag innerhalb eines Jahres Einsicht in ihre Masterarbeit, die darauf bezogenen Gutachten und in die Prüfungsprotokolle gewährt.
- (2) Für die Einsichtnahme in die schriftlichen Modulprüfungen bzw. Prüfungsprotokolle gilt eine Frist von einem Monat nach Bekanntgabe des Prüfungsergebnisses.
- (3) Die Prüferin bestimmt Ort und Zeit der Einsichtnahme.
- (4) Prüfungsunterlagen sind mindestens fünf Jahre aufzubewahren.

### **§ 24 In-Kraft-Treten**

- (1) Diese Studien- und Prüfungsordnung tritt am 1. Oktober 2008 in Kraft.
- (2) Gleichzeitig tritt die Prüfungsordnung der Universität Karlsruhe (TH) für den Diplomstudiengang Maschinenbau vom 27. Juli 2000 außer Kraft.
- (3) Studentinnen, die auf Grundlage der Prüfungsordnung für den Diplomstudiengang Maschinenbau vom 27. Juli 2000 (Amtliche Bekanntmachung der Universität Karlsruhe (TH) Nr. 18 vom 15. August 2000, S. 107 ff.) ihr Studium an der Universität Karlsruhe (TH) aufgenommen haben, können einen Antrag auf Zulassung zur Prüfung letztmalig am 30. September 2015 stellen.

Karlsruhe, den 28. Februar 2008

*Professor Dr. sc. tech. Horst Hippler  
(Rektor)*

---

# Amtliche Bekanntmachung

---

2014

Ausgegeben Karlsruhe, den 28. März 2014

Nr. 19

## Inhalt

Seite

|   |           |
|---|-----------|
| <b>Satzung zur Umsetzung des Übereinkommens über die<br/>Anerkennung von Qualifikationen im Hochschulbereich<br/>der Europäischen Region vom 11. April 1997 (Lissabon-<br/>Konvention) gemäß §§ 32 Abs. 2, 4 und 36a Landeshoch-<br/>schulgesetz (LHG) in den Studien- und Prüfungsordnungen<br/>am Karlsruher Institut für Technologie (KIT)</b> | <b>46</b> |
|---|-----------|

**Satzung zur Umsetzung des Übereinkommens über die Anerkennung von Qualifikationen im Hochschulbereich der Europäischen Region vom 11. April 1997 (Lissabon-Konvention) gemäß §§ 32 Abs. 2, 4 und 36a Landeshochschulgesetz (LHG) in den Studien- und Prüfungsordnungen am Karlsruher Institut für Technologie (KIT)**

**vom 27. März 2014**

Aufgrund von § 10 Absatz 2 Ziff. 5 und § 20 des Gesetzes über das Karlsruher Institut für Technologie (KIT-Gesetz - KITG) in der Fassung vom 14. Juli 2009 (GBl. S. 317 f), zuletzt geändert durch Artikel 5 des Gesetzes zur Einführung einer Verfassten Studierendenschaft und zur Stärkung der akademischen Weiterbildung (Verfasste-Studierendenschafts-Gesetz – VerfStudG) in der Fassung vom 10. Juli 2012 (GBl. S. 457, 464), und § 8 Absatz 5 und § 34 Absatz 1 des Gesetzes über die Hochschulen in Baden-Württemberg (Landeshochschulgesetz - LHG) in der Fassung vom 1. Januar 2005 (GBl. S. 1 f), zuletzt geändert durch Artikel 2 des Gesetzes zur Einführung einer Verfassten Studierendenschaft und zur Stärkung der akademischen Weiterbildung (Verfasste-Studierendenschafts-Gesetz – VerfStudG) in der Fassung vom 10. Juli 2012 (GBl. S. 457ff), wurde die folgende Satzung am 21. März 2014 durch Eilentscheidung des Präsidenten beschlossen.

Der Präsident hat seine Zustimmung gemäß § 20 Absatz 2 KITG iVm. § 34 Absatz 1 Satz 3 LHG am 27. März 2014 erteilt.

**Inhaltsverzeichnis**

**Artikel 1: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Angewandte Geowissenschaften**

**Artikel 2: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Architektur**

**Artikel 3: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Bauingenieurwesen**

**Artikel 4: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Bioingenieurwesen**

**Artikel 5: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Biologie**

**Artikel 6: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Chemie**

**Artikel 7: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Chemieingenieurwesen und Verfahrenstechnik**

**Artikel 8: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Chemische Biologie**

**Artikel 9: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Elektrotechnik und Informationstechnik**

**Artikel 10: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Geodäsie und Geoinformatik**

**Artikel 11: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Geoökologie**

**Artikel 12: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Geophysik**

**Artikel 13: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Informatik**

**Artikel 14: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Informationswirtschaft**

**Artikel 15: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Ingenieurpädagogik Bautechnik**

**Artikel 16: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Ingenieurpädagogik Elektrotechnik**

- Artikel 17: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Ingenieurpädagogik Metalltechnik
- Artikel 18: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Lebensmittelchemie
- Artikel 19: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Maschinenbau
- Artikel 20: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Materialwissenschaft und Werkstofftechnik (MWT)
- Artikel 21: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Mathematik
- Artikel 22: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Mechatronik und Informationstechnik
- Artikel 23: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Meteorologie
- Artikel 24: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Physik
- Artikel 25: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Sportwissenschaft
- Artikel 26: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Technische Volkswirtschaftslehre
- Artikel 27: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Wirtschaftsingenieurwesen
- Artikel 28: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang Wissenschaft-Medien-Kommunikation
- Artikel 29: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für die geistes- und sozialwissenschaftlichen Studiengänge mit akademischer Abschlussprüfung (B.A./M.A.-Studiengänge)
- Artikel 30: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den B.A./M.A.-Studiengang Kunstgeschichte
- Artikel 31: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den weiterbildenden Masterstudiengang Altbauinstandsetzung
- Artikel 32: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Angewandte Geowissenschaften
- Artikel 33: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Architektur
- Artikel 34: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Bauingenieurwesen
- Artikel 35: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Bioingenieurwesen
- Artikel 36: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Biologie
- Artikel 37: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Chemie
- Artikel 38: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Chemieingenieurwesen und Verfahrenstechnik
- Artikel 39: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Chemische Biologie
- Artikel 40: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für die weiterbildenden Masterstudiengänge Energy Engineering and Management (EEM), Green Mobility Engineering (GME), Production and Operations Management (POM), Management of Product Development (MPD), Electronic Systems Engineering and Management (ESEM)

**Artikel 41: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den englischsprachigen Weiterbildungsstudiengang mit Masterabschluss in Electrical Engineering and Information Technologies**

**Artikel 42: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Elektrotechnik und Informationstechnik**

**Artikel 43: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Energietechnik**

**Artikel 44: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Energy Technologies (ENTECH)**

**Artikel 45: Änderung der Studien- und Prüfungsordnung für den Masterstudiengang Funktionaler und konstruktiver Ingenieurbau – Engineering Structures**

**Artikel 46: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Geodäsie und Geoinformatik**

**Artikel 47: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Geoökologie**

**Artikel 48: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Geophysik**

**Artikel 49: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Informatik**

**Artikel 50: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Informationswirtschaft**

**Artikel 51: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Ingenieurpädagogik Bautechnik**

**Artikel 52: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Ingenieurpädagogik Elektrotechnik**

**Artikel 53: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Ingenieurpädagogik Metalltechnik**

**Artikel 54: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Lebensmittelchemie**

**Artikel 55: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Maschinenbau**

**Artikel 56: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Materialwissenschaft und Werkstofftechnik (MWT)**

**Artikel 57: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Mathematik**

**Artikel 58: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Meteorologie**

**Artikel 59: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Mobilität und Infrastruktur**

**Artikel 60: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Optics & Photonics**

**Artikel 61: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den weiterbildenden Masterstudiengang Personalentwicklung - Berufs- und Betriebspädagogik**

**Artikel 62: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Physik**

**Artikel 63: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Regionalwissenschaft/Raumplanung**

**Artikel 64: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Resources Engineering**

**Artikel 65: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für die weiterbildenden Masterstudiengänge Service Management and Engineering (SME) und Financial Engineering (FE)**

zen kein wesentlicher Unterschied zu den Leistungen oder Abschlüssen besteht, die ersetzt werden sollen. Dabei ist kein schematischer Vergleich, sondern eine Gesamtbetrachtung vorzunehmen. Bezüglich des Umfangs einer zur Anerkennung vorgelegten Studienleistung (Anrechnung) werden die Grundsätze des ECTS herangezogen.

**(2)** Die Studierenden haben die für die Anerkennung erforderlichen Unterlagen vorzulegen. Studierende, die neu in den Masterstudiengang Lebensmittelchemie immatrikuliert wurden, haben den Antrag mit den für die Anerkennung erforderlichen Unterlagen innerhalb eines Semesters nach Immatrikulation zu stellen. Bei Unterlagen, die nicht in deutscher oder englischer Sprache vorliegen, kann eine amtlich beglaubigte Übersetzung verlangt werden. Die Beweislast dafür, dass der Antrag die Voraussetzungen für die Anerkennung nicht erfüllt, liegt beim Prüfungsausschuss.

**(3)** Werden Leistungen angerechnet, die nicht am KIT erbracht wurden, werden sie im Zeugnis als „anerkannt“ ausgewiesen. Liegen Noten vor, werden die Noten, soweit die Notensysteme vergleichbar sind, übernommen und in die Berechnung der Modulnoten und der Gesamtnote einbezogen. Sind die Notensysteme nicht vergleichbar, können die Noten umgerechnet werden. Liegen keine Noten vor, wird der Vermerk „bestanden“ aufgenommen.

**(4)** Bei der Anerkennung von Studien- und Prüfungsleistungen, die außerhalb der Bundesrepublik Deutschland erbracht wurden, sind die von der Kultusministerkonferenz und der Hochschulrektorenkonferenz gebilligten Äquivalenzvereinbarungen sowie Absprachen im Rahmen der Hochschulpartnerschaften zu beachten.

**(5)** Außerhalb des Hochschulsystems erworbene Kenntnisse und Fähigkeiten werden angerechnet, wenn sie nach Inhalt und Niveau den Studien- und Prüfungsleistungen gleichwertig sind, die ersetzt werden sollen und die Institution, in der die Kenntnisse und Fähigkeiten erworben wurden, ein genormtes Qualitätssicherungssystem hat. Die Anrechnung kann in Teilen versagt werden, wenn mehr als 50 Prozent des Hochschulstudiums ersetzt werden soll.

**(6)** Zuständig für Anerkennung und Anrechnung ist der Prüfungsausschuss. Im Rahmen der Feststellung, ob ein wesentlicher Unterschied im Sinne des Absatz 1 vorliegt, sind die zuständigen Fachvertreter/innen zu hören. Der Prüfungsausschuss entscheidet in Abhängigkeit von Art und Umfang der anzurechnenden Studien- und Prüfungsleistungen über die Einstufung in ein höheres Fachsemester.

#### **Artikel 55: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Maschinenbau**

In der Studien- und Prüfungsordnung für den Masterstudiengang Maschinenbau vom 28. Februar 2008 (Amtliche Bekanntmachung Nr. 79 vom 9. September 2008) erhält § 16 folgende Fassung:

#### **§ 16 Anerkennung von Studien- und Prüfungsleistungen, Studienzeiten**

**(1)** Studien- und Prüfungsleistungen sowie Studienzeiten, die in Studiengängen an staatlichen oder staatlich anerkannten Hochschulen und Berufsakademien der Bundesrepublik Deutschland oder an ausländischen staatlichen oder staatlich anerkannten Hochschulen erbracht wurden, werden auf Antrag der Studierenden anerkannt, sofern hinsichtlich der erworbenen Kompetenzen kein wesentlicher Unterschied zu den Leistungen oder Abschlüssen besteht, die ersetzt werden sollen. Dabei ist kein schematischer Vergleich, sondern eine Gesamtbetrachtung vorzunehmen. Bezüglich des Umfangs einer zur Anerkennung vorgelegten Studienleistung (Anrechnung) werden die Grundsätze des ECTS herangezogen.

**(2)** Die Studierenden haben die für die Anerkennung erforderlichen Unterlagen vorzulegen. Studierende, die neu in den Masterstudiengang Maschinenbau immatrikuliert wurden, haben den Antrag mit den für die Anerkennung erforderlichen Unterlagen innerhalb eines Semesters nach Immatrikulation zu stellen. Bei Unterlagen, die nicht in deutscher oder englischer Sprache vorliegen, kann eine amtlich beglaubigte Übersetzung verlangt werden. Die Beweislast dafür, dass der Antrag die Voraussetzungen für die Anerkennung nicht erfüllt, liegt beim Prüfungsausschuss.

(3) Werden Leistungen angerechnet, die nicht am KIT erbracht wurden, werden sie im Zeugnis als „anerkannt“ ausgewiesen. Liegen Noten vor, werden die Noten, soweit die Notensysteme vergleichbar sind, übernommen und in die Berechnung der Modulnoten und der Gesamtnote einbezogen. Sind die Notensysteme nicht vergleichbar, können die Noten umgerechnet werden. Liegen keine Noten vor, wird der Vermerk „bestanden“ aufgenommen.

(4) Bei der Anerkennung von Studien- und Prüfungsleistungen, die außerhalb der Bundesrepublik Deutschland erbracht wurden, sind die von der Kultusministerkonferenz und der Hochschulrektorenkonferenz gebilligten Äquivalenzvereinbarungen sowie Absprachen im Rahmen der Hochschulpartnerschaften zu beachten.

(5) Außerhalb des Hochschulsystems erworbene Kenntnisse und Fähigkeiten werden angerechnet, wenn sie nach Inhalt und Niveau den Studien- und Prüfungsleistungen gleichwertig sind, die ersetzt werden sollen und die Institution, in der die Kenntnisse und Fähigkeiten erworben wurden, ein genormtes Qualitätssicherungssystem hat. Die Anrechnung kann in Teilen versagt werden, wenn mehr als 50 Prozent des Hochschulstudiums ersetzt werden soll.

(6) Zuständig für Anerkennung und Anrechnung ist der Prüfungsausschuss. Im Rahmen der Feststellung, ob ein wesentlicher Unterschied im Sinne des Absatz 1 vorliegt, sind die zuständigen Fachvertreter/innen zu hören. Der Prüfungsausschuss entscheidet in Abhängigkeit von Art und Umfang der anzurechnenden Studien- und Prüfungsleistungen über die Einstufung in ein höheres Fachsemester.

#### **Artikel 56: Änderung der Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Materialwissenschaft und Werkstofftechnik (MWT)**

In der Studien- und Prüfungsordnung für den Masterstudiengang Materialwissenschaft und Werkstofftechnik (MWT) vom 30. Juni 2011 (Amtliche Bekanntmachung Nr. 38 vom 30. Juni 2011) erhält § 16 folgende Fassung:

#### **§ 16 Anerkennung von Studien- und Prüfungsleistungen, Studienzeiten**

(1) Studien- und Prüfungsleistungen sowie Studienzeiten, die in Studiengängen an staatlichen oder staatlich anerkannten Hochschulen und Berufsakademien der Bundesrepublik Deutschland oder an ausländischen staatlichen oder staatlich anerkannten Hochschulen erbracht wurden, werden auf Antrag der Studierenden anerkannt, sofern hinsichtlich der erworbenen Kompetenzen kein wesentlicher Unterschied zu den Leistungen oder Abschlüssen besteht, die ersetzt werden sollen. Dabei ist kein schematischer Vergleich, sondern eine Gesamtbetrachtung vorzunehmen. Bezüglich des Umfangs einer zur Anerkennung vorgelegten Studienleistung (Anrechnung) werden die Grundsätze des ECTS herangezogen.

(2) Die Studierenden haben die für die Anerkennung erforderlichen Unterlagen vorzulegen. Studierende, die neu in den Masterstudiengang MWT immatrikuliert wurden, haben den Antrag mit den für die Anerkennung erforderlichen Unterlagen innerhalb eines Semesters nach Immatrikulation zu stellen. Bei Unterlagen, die nicht in deutscher oder englischer Sprache vorliegen, kann eine amtlich beglaubigte Übersetzung verlangt werden. Die Beweislast dafür, dass der Antrag die Voraussetzungen für die Anerkennung nicht erfüllt, liegt beim Prüfungsausschuss.

(3) Werden Leistungen angerechnet, die nicht am KIT erbracht wurden, werden sie im Zeugnis als „anerkannt“ ausgewiesen. Liegen Noten vor, werden die Noten, soweit die Notensysteme vergleichbar sind, übernommen und in die Berechnung der Modulnoten und der Gesamtnote einbezogen. Sind die Notensysteme nicht vergleichbar, können die Noten umgerechnet werden. Liegen keine Noten vor, wird der Vermerk „bestanden“ aufgenommen.

(4) Bei der Anerkennung von Studien- und Prüfungsleistungen, die außerhalb der Bundesrepublik Deutschland erbracht wurden, sind die von der Kultusministerkonferenz und der Hochschulrektorenkonferenz gebilligten Äquivalenzvereinbarungen sowie Absprachen im Rahmen der Hochschulpartnerschaften zu beachten.

## Index

- A**
- Actual topics of BioMEMS ..... 484
  - Actuators and sensors in nanotechnology ..... 483
  - Adaptive Control Systems ..... 65, 478
  - Adsorption Technology for Heat Transformation - Systems and Applications ..... 479
  - Adsorption Technology for Heat Transformation – Materials and Principles ..... 480
  - Advanced Methods in Strength of Materials ..... 640
  - Advanced powder metals ..... 327, 784
  - Aerodynamics ..... 66, 481
  - Aerothermodynamics ..... 67, 482
  - Airport logistics ..... 222, 684
  - Analysis and Design of Multisensor Systems ..... 485
  - Analysis of Exhaust Gas und Lubricating Oil in Combustion Engines ..... 64, 477
  - Analysis tools for combustion diagnostics ..... 256, 712
  - Appliance and Power Tool Design ..... 607
  - Application of advanced programming languages in mechanical engineering ..... 73, 495
  - Application of technical logistics in modern crane systems ..... 71, 493
  - Application of technical logistics in sorting- and distribution technology ..... 72, 494
  - Applied Combustion Technology ..... 74
  - Applied Materials Modelling ..... 69, 488
  - Applied Tribology in Industrial Product Development ..... 68, 487
  - Atomistic simulations and molecular dynamics .. 78, 500
  - Automated Manufacturing Systems ..... 514
  - Automation Systems ..... 90, 516
  - Automotive Engineering I ..... 91, 171, 517, 616
  - Automotive Engineering II ..... 172, 518, 617
  - Automotive Logistics ..... 221, 683
  - Automotive Vision ..... 148, 587
- B**
- Basics and Methods for Integration of Tires and Vehicles ..... 147, 586
  - Basics of Liberalised Energy Markets ..... 93
  - Basics of Technical Logistics ..... 181, 626
  - Behaviour Generation for Vehicles ..... 390, 862
  - Bioelectric Signals ..... 526
  - Biomedical Measurement Techniques I ..... 527
  - Biomedical Measurement Techniques II ..... 528
  - BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I ..... 95, 529
  - BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II ..... 96, 530
  - BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III ..... 97, 531
  - Bionics for Engineers and Natural Scientists ..... 532
  - Building- and Environmental Aerodynamics ..... 605
  - BUS-Controls ..... 98, 533
- C**
- CAD-NX training course ..... 535
  - CAE-Workshop ..... 99, 536
  - CATIA advanced ..... 537
  - CATIA CAD training course ..... 534
  - Ceramics Processing ..... 204, 665
  - CFD for Power Engineering ..... 100, 538
  - CFD-Lab using Open Foam ..... 539
  - Chemical Fuels ..... 101
  - Coal fired power plants ..... 207, 670
  - Cognitive Automobiles - Laboratory ..... 668
  - Cognitive Systems ..... 669
  - Combined Cycle Power Plants ..... 160, 602
  - Combustion diagnostics ..... 389, 861
  - Composites for Lightweight Design ..... 149, 588
  - Compulsory Elective Subject EU (M) ..... 38
  - Compulsory Elective Subject FzgT (M) ..... 39
  - Compulsory Elective Subject General Mechanical Engineering (M) ..... 36
  - Compulsory Elective Subject MM (M) ..... 41
  - Compulsory Elective Subject PEK (M) ..... 43
  - Compulsory Elective Subject PT (M) ..... 44
  - Compulsory Elective Subject ThM (M) ..... 45
  - Compulsory Elective Subject WS (M) ..... 46
  - Computational Dynamics ..... 789
  - Computational Intelligence I ..... 102, 541
  - Computational Intelligence II ..... 103, 542
  - Computational Intelligence III ..... 104, 543
  - Computational Mechanics I ..... 335, 793
  - Computational Mechanics II ..... 336, 794
  - Computational methods for the heat protection of a full vehicle ..... 375, 845
  - Computational Methods in Fluid Mechanics ... 283, 739
  - Computational Vehicle Dynamics ..... 332, 790
  - Computer Engineering ..... 367, 839
  - Computer Integrated Planning of New Products ..... 334, 792
  - Computerized Multibody Dynamics ..... 333, 791
  - Constitution and Properties of Protective Coatings .. 80, 502
  - Constitution and Properties of Wear resistant materials ..... 79, 501
  - Control Technology ..... 350, 822
  - Cooling of thermally high loaded gas turbine components ..... 213, 676

- D**
- Decentrally controlled intralogistic systems ..... 105
  - Decommissioning of Nuclear Facilities I ..... 800
  - Design and Development of Mobile Machines .. 88, 512
  - Design of combustion chamber in gas turbines (Project) 510
  - Design of highly stresses components ..... 87, 511
  - Design Project Machine Tools and Industrial Handling 573
  - Design with Plastics ..... 208, 671
  - Designing with composites ..... 110, 548
  - Designing with numerical methods in product development ..... 109, 547
  - Development of Oil-Hydraulic Powertrain Systems . 323, 780
  - Digital Control ..... 108, 546
  - Dimensioning and Optimization of Power Train System 89, 513
  - Drive Systems and Possibilities to Increase Efficiency 490
  - Drive Train of Mobile Machines ..... 70, 489
  - Dynamics of mechanical Systems with tribological Contacts ..... 549
  - Dynamics of the Automotive Drive Train ..... 111, 550
- E**
- Elective Subject (M) ..... 47
  - Elective Subject Economics/Law (M) ..... 61
  - Elective Subject Natural Science/Computer Science/Electrical Engineering (M) ..... 60
  - Electric Power Generation and Power Grid ..... 124
  - Electric Rail Vehicles ..... 128, 564
  - Electrical Engineering II ..... 129
  - Electrical Machines ..... 125
  - Electrical Power Transmission and Grid Control .... 127
  - Elements of Technical Logistics ..... 130, 565
  - Elements of Technical Logistics and Project ... 131, 566
  - Energy and Process Technology I ..... 132
  - Energy and Process Technology II ..... 133
  - Energy Conversion and Increased Efficiency in Internal Combustion Engines ..... 572
  - Energy efficient intralogistic systems ..... 134, 568
  - Energy Systems I: Renewable Energy ..... 135, 569
  - Energy Systems II: Nuclear Energy and Reactor Technology ..... 136, 571
  - Energy systems II: Reactor Technology ..... 570
  - Engine Laboratory ..... 271, 727
  - Engine measurement techniques ..... 272, 728
  - Evaluation of welded joints ..... 523
  - Experimental Dynamics ..... 576
  - Experimental Fluid Mechanics ..... 138, 577
- F**
- Fabrication Processes in Microsystem Technology . 151, 590
  - Failure of structural materials: deformation and fracture 392, 865
  - Failure of Structural Materials: Fatigue and Creep . 391, 863
  - Fatigue of Metallic Materials ..... 341, 806
  - FEM Workshop – constitutive laws ..... 150, 589
  - Finite Difference Methods for numerical solution of thermal and fluid dynamical problems ..... 107, 545
  - Finite Element Workshop ..... 594
  - Finite Volume Methods for Fluid Flow ..... 153, 595
  - Flow Simulations with OpenFOAM ..... 829
  - Flows and Heat Transfer in Energy Technology 355, 828
  - Flows in rotating systems ..... 353, 826
  - Flows with chemical reactions ..... 354, 827
  - Fluid Mechanics of Turbulent Flows ..... 597
  - Fluid Technology ..... 155, 598
  - Fluid-Structure-Interaction ..... 154, 596
  - Foundations of nonlinear continuum mechanics .... 178, 623
  - Foundry Technology ..... 164, 609
  - Fuels and Lubricants for Combustion Engines .. 94, 521
  - Functional Ceramics ..... 157, 599
  - Fundamentals for Design of Motor-Vehicles Bodies 1632
  - Fundamentals for Design of Motor-Vehicles Bodies II 1633
  - Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises) .... 380, 850
  - Fundamentals in the Development of Commercial Vehicles I ..... 634
  - Fundamentals in the Development of Commercial Vehicles II ..... 635
  - Fundamentals of Automobile Development I ..... 636
  - Fundamentals of Automobile Development II ..... 637
  - Fundamentals of catalytic exhaust gas aftertreatment 174, 619
  - Fundamentals of Combustion Engines I ..... 184, 629
  - Fundamentals of Combustion Engines II ..... 185, 630
  - Fundamentals of Combustion I ..... 156, 182, 627
  - Fundamentals of combustion II ..... 183, 628
  - Fundamentals of Energy Technology ..... 170, 615
  - Fundamentals of reactor safety for the operation and dismantling of nuclear power plants .. 179, 624
  - Fundamentals of X-ray Optics I ..... 180, 625
  - Fusion Technology A ..... 158, 600
  - Fusion Technology B ..... 159, 601
- G**
- Gas Engines ..... 162, 604
  - Gear Cutting Technology ..... 394, 867
  - Global Production and Logistics - Part 1: Global Production ..... 165, 610
  - Global Production and Logistics - Part 2: Global Logistics ..... 167, 612
  - Global vehicle evaluation within virtual road test ... 163, 608

- Grundlagen der Herstellungsverfahren der Keramik und Pulvermetallurgie ..... 173, 618
- H**
- Handling Characteristics of Motor Vehicles I... 141, 580  
 Handling Characteristics of Motor Vehicles II .. 142, 581  
 Hardware/Software Codesign ..... 187  
 Heat and mass transfer ..... 399  
 Heat Transfer in Nuclear Reactors..... 401, 873  
 Heatpumps ..... 400, 872  
 High Performance Computing ..... 638  
 High Temperature Structural Materials ..... 188, 639  
 Human Biology ..... 189  
 Human brain and central nervous system: anatomy, information transfer, signal processing, neuro-physiology and therapy ..... 606  
 Human Factors Engineering I..... 75, 496  
 Human Factors Engineering II..... 77, 498  
 Human Factors Lab ..... 499  
 Human-Machine-Interaction ..... 708  
 Hybrid and Electric Vehicles ..... 641  
 Hydraulic Fluid Machinery I (Basics) ..... 190, 643  
 Hydraulic Fluid Machinery II..... 191, 644  
 Hydrodynamic Stability: From Order to Chaos. 192, 645  
 Hydrogen Technologies ..... 403, 874
- I**
- Industrial aerodynamics ..... 193, 646  
 Information Engineering ..... 650  
 Information Processing in Mechatronic Systems .... 652  
 Information Processing in Sensor Networks ..... 653  
 Information Systems in Logistics and Supply Chain Management ..... 197, 651  
 Innovation Workshop: Mobility concepts for the year 2050..... 198, 654  
 Innovative Nuclear Systems ..... 199, 655  
 Integrated Information Systems for engineers ..... 368  
 Integrated measurement systems for fluid mechanics applications ..... 657  
 Integrated Product Development ..... 658  
 Integrated production planning ..... 659  
 Integrative Strategies in Production and Development of High Performance Cars ..... 656  
 Intellectual Property Rights and Strategies in Industrial Companies ..... 289, 744  
 Introduction to numerical mechanics ..... 121, 559  
 Introduction in Human Factors Engineering ..... 112  
 Introduction into Mechatronics ..... 118, 556  
 Introduction into the multi-body dynamics ..... 119, 557  
 Introduction to Automotive Lightweight Technology. 145, 584  
 Introduction to Ceramics ..... 203, 664  
 Introduction to Industrial Production Economics.... 194, 647  
 Introduction to Microsystem Technology - Practical Course ..... 306, 764
- Introduction to Microsystem Technology I..... 176, 621  
 Introduction to Microsystem Technology II ..... 177, 622  
 Introduction to modeling of aerospace systems 120, 558  
 Introduction to Neutron Cross Section Theory and Nuclear Data Generation..... 200, 661  
 Introduction to Nonlinear Vibrations ..... 122, 562  
 Introduction to Nuclear Energy ..... 114, 552  
 Introduction to Nuclear Engineering ..... 115, 553  
 Introduction to numerical fluid dynamics ..... 560  
 Introduction to the Finite Element Method ..... 113, 551  
 Introduction to the Mechanics of Composite Materials 117, 555  
 Introduction to Theory of Materials ..... 116, 554  
 IT-Fundamentals of Logistics ..... 201, 662
- L**
- Lab Computer-aided methods for measurement and control ..... 762  
 Laboratory "Laser Materials Processing" ..... 305, 761  
 Laboratory Exercise in Energy Technology .... 219, 681  
 Laboratory mechatronics ..... 251, 707  
 Laboratory Work in Combustion Technology ..... 214  
 Laser in automotive engineering ..... 217, 679  
 Leadership and Conflict Management (in German). 226, 689  
 Leadership and Product Development..... 218, 680  
 Lectures in English (M.Sc.) (M)..... 62  
 Lightweight Engineering Design ..... 210, 672  
 Localization of Mobile Agents ..... 685  
 Logistics - organisation, design and control of logistic systems ..... 220, 682  
 Low Temperature Technology ..... 486
- M**
- Machine Dynamics..... 228, 691  
 Machine Dynamics II..... 229, 692  
 Machine Tools and Industrial Handling ..... 880  
 Machine Vision ..... 223, 686  
 Magnet Technology of Fusion Reactors ..... 224, 687  
 Magnetohydrodynamics ..... 225, 688  
 Major Field 1 (M) ..... 58  
 Major Field 2 (M) ..... 59  
 Manufacturing Technology ..... 591  
 Material Analysis..... 405, 876  
 Material flow in logistic systems ..... 230, 693  
 Materialien für elektrochemische Speicher und Wandler 231  
 Materials and Processes for Body Lightweight Construction in the Automotive Industry..... 232, 694  
 Materials for Lightweight Construction..... 406, 877  
 Materials modelling: dislocation based plasticity 407, 879  
 Materials Science and Engineering III ..... 878  
 Materials under high thermal or neutron loads. 374, 844  
 Mathematic Methods (M) ..... 57

- Mathematical Foundation for Computational Mechanics  
234, 695
- Mathematical Methods in Dynamics ..... 235, 696
- Mathematical Methods in Fluid Mechanics .... 239, 699
- Mathematical Methods in Strength of Materials 236, 697
- Mathematical Methods in Structural Mechanics 240, 700
- Mathematical methods of vibration theory ..... 238, 698
- Mathematical Modelling and Simulation ..... 233
- Mathematical models and methods for Production Systems ..... 243, 702
- Mathematical models and methods in combustion theory  
242, 701
- Measurement II ..... 252, 711
- Measurement Instrumentation Lab ..... 253
- Measurement technique for fluid mechanics ..... 710
- Measurement Technology ..... 709
- Mechanical Characteristics and Microstructure Characteristics Relationships ..... 250
- Mechanical Design I ..... 245
- Mechanics and Strengths of Polymers ..... 248, 705
- Mechanics in Microtechnology ..... 249, 706
- Mechanics of laminated composites ..... 247, 704
- Mechatronic Softwaretools ..... 819
- Medical Imaging Techniques I ..... 524
- Medical Imaging Techniques II ..... 525
- Medical Robotics ..... 799
- Metal Forming ..... 386, 857
- Metallographic Lab Class ..... 139, 578
- Metals ..... 254
- Methodic Development of Mechatronic systems .... 713
- Methodical Design of Composite Structures ... 257, 714
- Methods of Signal Processing ..... 255
- Microactuators ..... 259, 717
- Microenergy Technologies ..... 715
- Microoptics and Lithography ..... 258, 716
- Microstructure characterization and modelling. 260, 718
- Mobile Machines ..... 263, 721
- Model based Application Methods ..... 264, 722
- Modeling and Simulation (M) ..... 54
- Modeling of Thermodynamical Processes ..... 266, 723
- Modelling and Simulation ..... 265, 267, 724
- Modelling of Microstructures ..... 261, 719
- Modern Control Concepts I ..... 726
- Modern Physics for Engineers ..... 270
- Modern Software Tools in Power Engineering ..... 269
- Motor Vehicle Laboratory ..... 212, 675
- Multi-scale Plasticity ..... 749
- Multilingual Human-Machine Communication ..... 729
- N**
- Nanotechnology for Engineers and Natural Scientists  
273, 730
- Nanotechnology with Clusterbeams ..... 274, 731
- Nanotribology and -Mechanics ..... 275, 732
- Neutron physics of fusion reactors ..... 277, 734
- Nonlinear Continuum Mechanics ..... 278, 735
- Novel actuators and sensors ..... 276, 733
- Nuclear Fuel Cycle and Radiochemistry ..... 787
- Nuclear Fusion Technology ..... 279
- Nuclear Power and Reactor Technology ..... 280
- Nuclear Power Plant Technology ..... 205, 666
- Nuklear Medicine and Nuklear Medicine Measurement  
Technics I ..... 736
- Numerical Fluid Mechanics with MATLAB ..... 743
- Numerical Mathematics ..... 281, 737
- Numerical mechanics for industrial applications 282, 738
- Numerical Modeling of Multiphase Flows ..... 284, 740
- Numerical simulation of reacting two phase flows .. 285, 741
- Numerical Simulation of Turbulent Flows ..... 286, 742
- O**
- Occupational Safety and Environmental Protection (in  
German) ..... 195, 648
- Operation ..... 520
- Operation Systems and Track Guided Infrastructure Capacity ..... 522
- Optical Flow Measurement: Fundamentals and Applications ..... 186, 631
- Optoelectronic Components ..... 288
- Organ support systems ..... 137, 575
- P**
- Patent Law ..... 290
- Photovoltaics ..... 291, 745
- Physical basics of laser technology ..... 293
- Physics for Engineers ..... 292
- Planning of Assembly Systems (in German) ... 295, 747
- PLM for Product Development in Mechatronics 296, 750
- PLM in the Manufacturing Industry ..... 297, 751
- Polymer Engineering I ..... 298, 752
- Polymer Engineering II ..... 299, 753
- Polymers in MEMS A: Chemistry, Synthesis and Applications ..... 300, 754
- Polymers in MEMS B: Physics, Microstructuring and Applications ..... 302, 756
- Power and Heat economics ..... 674
- Power Electronics ..... 304
- Powertrain Systems Technology A: Automotive Systems  
491
- Powertrain Systems Technology B: Stationary Machinery ..... 492
- Practical Course Technical Ceramics ..... 763
- Principles of Medicine for Engineers ..... 175, 620
- Probability Theory and Statistics ..... 402
- Process Simulation in Forming Operations .... 326, 783
- Product Development (M) ..... 55
- Product Development - Manufacturing and Material  
Technology ..... 311
- Product Development - Methods of Product Development ..... 310

- Product Lifecycle Management ..... 307, 765
- Product, Process and Resource Integration in the Automotive Industry ..... 309, 767
- Production Management I ..... 313, 768
- Production Management II ..... 314, 769
- Production Planning and Control ..... 315, 770
- Production Techniques Laboratory ..... 317, 772
- Production Technology and Management in Automotive ..... 774
- Productivity Management in Production Systems .. 319, 776
- Project management in Global Product Engineering Structures ..... 325, 782
- Project Management in Rail Industry ..... 324, 781
- Project Mikro Manufacturing: Design and Manufacturing of Micro Systems ..... 322, 779
- Project Workshop: Automotive Engineering ... 321, 778
- Public Law I - Basic Principles ..... 287
- Q**
- Quality Management ..... 328, 785
- R**
- Radiation Protection I: Ionising Radiation ..... 824
- Rail System Technology ..... 92, 519
- Rail Vehicle Technology ..... 340, 801
- Railways in the Transportation Market ..... 106, 544
- Range Extender ..... 330
- Reactor Safety I: Fundamentals ..... 331, 788
- Reduction methods for the modeling and the simulation of combustion processes ..... 337, 795
- Renewable Energy – Resources, Technology and Economics ..... 338
- Rheometry and Rheology ..... 339
- Robotics I – Introduction to robotics ..... 796
- Robotics II - Learning and planning robots ..... 797
- Robotik III - Sensors in Robotics ..... 798
- S**
- Safety Engineering ..... 343, 809
- Scaling in fluid dynamics ..... 348, 818
- Schwingungstechnisches Praktikum ..... 342, 807
- Scientific computing for Engineers ..... 409, 884
- Selected Applications of Technical Logistics .... 81, 503
- Selected Applications of Technical Logistics and Project ..... 504
- Selected chapters of the combustion fundamentals . 85, 508
- Selected Problems of Applied Reactor Physics and Exercises ..... 86, 509
- Selected Topics in Aeronautics and Astronautics I ... 82, 505
- Selected Topics in Aeronautics and Astronautics II .. 83, 506
- Selected Topics on Optics and Microoptics for Mechanical Engineers ..... 84, 507
- Signals and Systems ..... 810
- Simulation Aided Management ..... 815
- Simulation in product development process ..... 812
- Simulation of Coupled Systems ..... 345, 811
- Simulation of production systems and processes .. 346, 813
- Simulator Exercises Combined Cycle Power Plants . 817
- Size effects in micro and nanostructures materials . 169, 614
- Solid State Reactions and Kinetics of Phase Transformations (with exercises) ..... 152, 593
- SP 01: Advanced Mechatronics (SP) ..... 412
- SP 02: Powertrain Systems (SP) ..... 414
- SP 03: Human Factors Engineering (SP) ..... 415
- SP 04: Automation Technology (SP) ..... 416
- SP 05: Calculation Methods in Mechanical Engineering (SP) ..... 417
- SP 06: Computational Mechanics (SP) ..... 419
- SP 08: Dynamics and Vibration Theory (SP) ..... 421
- SP 09: Dynamic Machine Models (SP) ..... 422
- SP 10: Engineering Design (SP) ..... 423
- SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (SP) ..... 425
- SP 12: Automotive Technology (SP) ..... 426
- SP 15: Fundamentals of Energy Technology (SP) .. 428
- SP 16: Industrial Engineering (SP) ..... 429
- SP 18: Information Technology (SP) ..... 430
- SP 19: Information Technology of Logistic Systems (SP) ..... 431
- SP 20: Integrated Product Development (SP) ..... 432
- SP 21: Nuclear Energy (SP) ..... 433
- SP 22: Cognitive Technical Systems (SP) ..... 434
- SP 23: Power Plant Technology (SP) ..... 435
- SP 24: Energy Converting Engines (SP) ..... 437
- SP 25: Lightweight Construction (SP) ..... 438
- SP 26: Materials Science and Engineering (SP) .... 440
- SP 27: Modeling and Simulation in Energy- and Fluid Engineering (SP) ..... 442
- SP 28: Lifecycle Engineering (SP) ..... 443
- SP 29: Logistics and Material Flow Theory (SP) .... 444
- SP 30: Applied Mechanics (SP) ..... 445
- SP 31: Mechatronics (SP) ..... 446
- SP 32: Medical Technology (SP) ..... 448
- SP 33: Microsystem Technology (SP) ..... 450
- SP 34: Mobile Machines (SP) ..... 451
- SP 35: Modeling and Simulation (SP) ..... 452
- SP 36: Polymer Engineering (SP) ..... 454
- SP 37: Production Management (SP) ..... 455
- SP 39: Production Technology (SP) ..... 456
- SP 40: Robotics (SP) ..... 458
- SP 41: Fluid Mechanics (SP) ..... 460
- SP 43: Technical Ceramics and Powder Materials (SP) ..... 462
- SP 44: Technical Logistics (SP) ..... 463

- SP 45: Engineering Thermodynamics (SP) ..... 464  
 SP 46: Thermal Turbomachines (SP) ..... 465  
 SP 47: Tribology (SP) ..... 466  
 SP 49: Reliability in Mechanical Engineering (SP) .. 467  
 SP 50: Rail System Technology (SP) ..... 469  
 SP 51: Development of innovative appliances and power tools (SP) ..... 470  
 SP 53: Fusion Technology (SP) ..... 471  
 SP 54: Microactuators and Microsensors (SP) ..... 472  
 SP 55: Energy Technology for Buildings (SP) ..... 473  
 SP 56: Advanced Materials Modelling (SP) ..... 474  
 Specialized Practical Training (M) ..... 56  
 Strategic Product Planing ..... 352, 825  
 Structural and phase analysis ..... 356, 830  
 Structural Ceramics ..... 357, 831  
 Structural Materials ..... 209  
 Superconducting Materials for Energy Applications . 358  
 Superhard Thin Film Materials ..... 359, 832  
 Supply chain management ..... 360, 833  
 Sustainable Product Engineering ..... 361, 834  
 System Integration in Micro- and Nanotechnology .. 835  
 Systematic Materials Selection ..... 362  
 Systems and Software Engineering ..... 363
- T**
- Technical Acoustics ..... 366, 836  
 Technical Design in Product Development ..... 371, 841  
 Technology of steel components ..... 372, 842  
 Ten lectures on turbulence ..... 373, 843  
 The Management of R&D Projects with Case Studies  
     140  
 Theoretical Description of Mechatronic Systems .... 365  
 Theory of Stability ..... 349, 821  
 Thermal Solar Energy ..... 376, 846  
 Thermal Turbomachines I ..... 378, 848  
 Thermal Turbomachines II ..... 379, 849  
 Thin film and small-scale mechanical behavior ..... 851  
 Track Guided Transport Systems - Technical Design and Components ..... 820  
 Tractors ..... 381, 852  
 Tribology ..... 382, 853  
 Turbine and compressor Design ..... 383, 854  
 Turbo Jet Engines ..... 384, 855  
 Tutorial for Heat Transfer in Nuclear Reactors . 385, 856  
 Two-Phase Flow and Heat Transfer ..... 410, 885
- V**
- Vacuum and Tritium Technology ..... 388  
 Vehicle Comfort and Acoustics I ..... 143, 582  
 Vehicle Comfort and Acoustics II ..... 144, 583  
 Vehicle Mechatronics I ..... 146, 585  
 Vehicle Ride Comfort & Acoustics I ..... 859  
 Vehicle Ride Comfort & Acoustics II ..... 860  
 Vibration of continuous systems ..... 211, 673  
 Vibration Theory ..... 369, 840  
 Virtual Engineering (Specific Topics) ..... 396  
 Virtual Engineering I ..... 397, 869  
 Virtual Engineering II ..... 398, 870  
 Virtual Reality Laboratory ..... 871
- W**
- Warehousing and distribution systems ..... 215, 677  
 Wave propagation ..... 561  
 Wave Propagation ..... 404, 875  
 Welding Lab Course, in groupes ..... 579  
 Welding Technology I ..... 802  
 Welding Technology II ..... 804  
 Wind and Hydropower ..... 408, 882  
 Windpower ..... 883