Karlsruher Institut für Technologie

Module Handbook
Computational Modeling in Engineering (Master of Science)

SPO 2026

Winter semester 2026/27

Date: 01/09/2026

KIT DEPARTMENT OF CHEMICAL AND PROCESS ENGINEERING / KIT DEPARTMENT OF MECHANICAL ENGINEERING

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1 General Information

1.1 Study program details

KIT-Department	**KIT Department of Chemical and Process Engineering / KIT Department of Mechanical Engineering**
Academic Degree	**Master of Science (M.Sc.)**
Examination Regulations Version	**2026**
Regular semesters	**4 semesters**
Maximum semesters	**8 semesters**
Credits	**120**
Language	**English**
Grade calculation	**Weighted by (Weight * CP)**
Additional Information	**Department** https://www.mach.kit.edu/english/5282.php **Business unit Studium und Lehre** https://www.sle.kit.edu/english/vorstudium/master-computational-modeling-engineering.php

1.2 Content

The program provides a solid foundation in applied mathematical and physical modeling, complemented by specialized numerical and data-driven methods that are essential in modern engineering practice. As a student, you will learn to develop, analyze, and critically evaluate complex computational models while working in interdisciplinary teams that reflect real-world engineering environments. The curriculum combines fundamental theory with practical applications across various fields of engineering, equipping you with a portfolio of skills that is both academically rigorous and highly relevant for your future career. Awide range of elective courses allows you to tailor your studies to your personal interests - whether you are passionate about materials science, fluid dynamics, structural mechanics, or innovative data-based methods.

The master's degree program is taught entirely in English and can be started in either the winter or summer semester

Credit points (CP) are awarded in accordance with the "European Credit Transfer and Accumulation System" (ECTS) and are based on the workload to be completed by students. In this context, 30 hours of work correspond to one CP.

Structure of the degree program

The degree program is divided into six subjects: Master’s Thesis, Project, Interdisciplinary Electives (ungraded), Methods, Computational Engineering and Applications and Core Competencies.

In the modules of the subject *Interdisciplinary Electives*, students must choose one or more courses from the lists provided in the module handbook.

In the subjects *Methods* and *Computational Engineering and Applications*, students choose modules adding up to 24 CP each from the course catalog. Students should decide on an individual focus and reflect it in an individual study plan. If advice is required, please contact InSL student advisory service or email cme@mach.kit.edu

The subject *Master’s Thesis* consists of the master's thesis module and the subject *Project* consists of the project module. The project module has an individual title depending on the student’s choice of topic (For more information, see the details of the project module).

- **Recomended Study Plan**

We recommend using the first two semesters to complete the courses in Core Competencies. The subjects Methods and Computational Engineering and Applications can be started in the first semester and should be completed by the end of the third semester. The Project is planned for the third semester, but can also be completed earlier, if it fits into the individual study plan. The fourth semester is dedicated to the master’s thesis.

- **Methods**

Courses amounting to 24 CP are selected. The credit value of the courses is either 4, 6 or 8 credits making it possible to assign courses freely to different semesters until 24 CP are reached. It is not permitted to register for additional exams once 24 CP have been reached or exceeded. If desired, additional courses can be added as supplementary studies.

The grade for Methods is calculated based on the module components completed with an examination. As a rule, all module components are weighted according to their credit points. When calculating the overall grade, Methods is weighted with 24 CP.

The description of the courses offered in Methods, including the module components, is outlined in the current module handbook of the master's degree program

- **Computational Engineering and Applications**

Courses amounting to 24 CP are selected. The credit value of the courses is either 4, 6 or 8 credits making it possible to assign courses freely to different semesters until 24 CP are reached. It is not permitted to register for additional exams once 24 CP have been reached or exceeded. If desired additional courses can be added as supplementary studies.

The grade for Computational Engineering and Applications is calculated based on the completed module components. As a rule, all module components are weighted according to their credit points. When calculating the overall grade, Computational Engineering and Applications is weighted with 24 CP.

The description of the courses offered in Computational Engineering and Applications, including the module components, is outlined in the current module handbook of the master's degree program.

Examinations and Evaluation of Success

The master’s examination consists of module examinations. Module examinations consist of one or more evaluations of success (ES). ES are divided into coursework (CW) and examinations. CW is ungraded, while examinations are graded. Examinations are divided into written examinations (WE), oral examinations (OE) or examinations of another type (Eoat). The type of ES depends on the individual choice of courses.

At least one examination date is offered for examinations each semester. Examination dates and the latest dates by which students must register for examinations are set by the Examination Board. As a rule, students must register for examinations at least one week before the examination. Registration deadlines and examination dates are announced in good time and, in the case of written examinations at least six weeks before the examination.

The examiner decides which aids may be used in an examination. A list of permitted aids will be published at the same time as the examination date is announced.

Coursework can be repeated as often as required until it has been successfully completed. A failed written or oral examination or an examination of another type may be repeated once. If a written repeat examination is assessed as “insufficient”, an oral continuation of the repeat examination (oral re-examination) will take place at the same time. For all other regulations, please refer to §8 of the SER.

For the assessment of coursework and examinations and the calculation of module and subject grades, please refer to §7 of the SER and the information in this module handbook about the individual modules.

1.3 Qualification Goals

Graduates of the **Master’s program in Computational Modeling in Engineering** at the Karlsruhe Institute of Technology (KIT) are qualified to contribute to value-creation processes across a broad spectrum of engineering disciplines, without being restricted to a specific field of application. Their research-oriented education also prepares them for academic careers. In particular, they are well-suited to roles in industry, technical services, and scientific research, while also meeting the prerequisites for pursuing a doctoral degree.

Graduates of the program are able to:

- **Develop and explain** mathematical and physical models for complex technical systems
- **Validate and analyze** these models using data-driven methods and apply them to engineering challenges
- **Critically assess and evaluate** new findings in their field through independent scientific reasoning

Graduates are proficient in:

- **Applying** their acquired experimental, analytical, and numerical methods to independently address and solve complex engineering problems across a broad range of application domains in international research and development environments and research institutions.
- **Describing** complex interrelations through models, selecting appropriate modeling paradigms, implementing, simulating, and visualizing these models, and analyzing their results
- **Critically evaluating** results from the analysis and simulation of complex systems and deriving conclusions for assessments, interventions, and further development
- **Successfully analyzing and addressing** novel challenges in an increasingly complex technical landscape through interdisciplinary, project-based, and team-oriented collaboration.

Graduates are prepared to:

- **Transfer** cutting-edge research findings into engineering practise by drawing on the close integration of research and teaching
- **Independently pursue** responsible and sustainable engineering careers grounded in scientific knowledge
- **Critically assess data** with regard to holistic and sustainable solutions to engineering problems

Furthermore, building on their bachelor-level qualifications, graduates are capable of:

- **Identifying and classifying** similarities in the mathematical approaches to various engineering problems to develop targeted solutions
- **Reflecting systematically** on non-technical impacts of engineering work and incorporating these considerations responsibly into their professional practice
- **Developing solutions** that require advanced methodological expertise

1.4 Acceptance Criterias

Whether admission is possible depends on your previous academic knowledge, i.e. the content of the Bachelor's degree course you have completed. You must provide evidence of the following academic achievements from your previous studies:

- B. Sc. Engineering program with a grade of 2.3 or better.
- Engineering and/or natural sciences background with at least 40 ECTS.
- Mathematical knowledge with at leasr 15 ECTS in your bachelor's degree.
- Sufficient English language skills.

The best candidates will then be invited to a selection interview, after which the final admission decision is made.

Further details on the application can be found in the admission regulations.
https://www.sle.kit.edu/downloads/AmtlicheBekanntmachungen/2021_AB_023.pdf

English Version (Not legally binding)

1.5 Contact

cme@mach.kit.edu

1.6 Studies and Examination Regulations

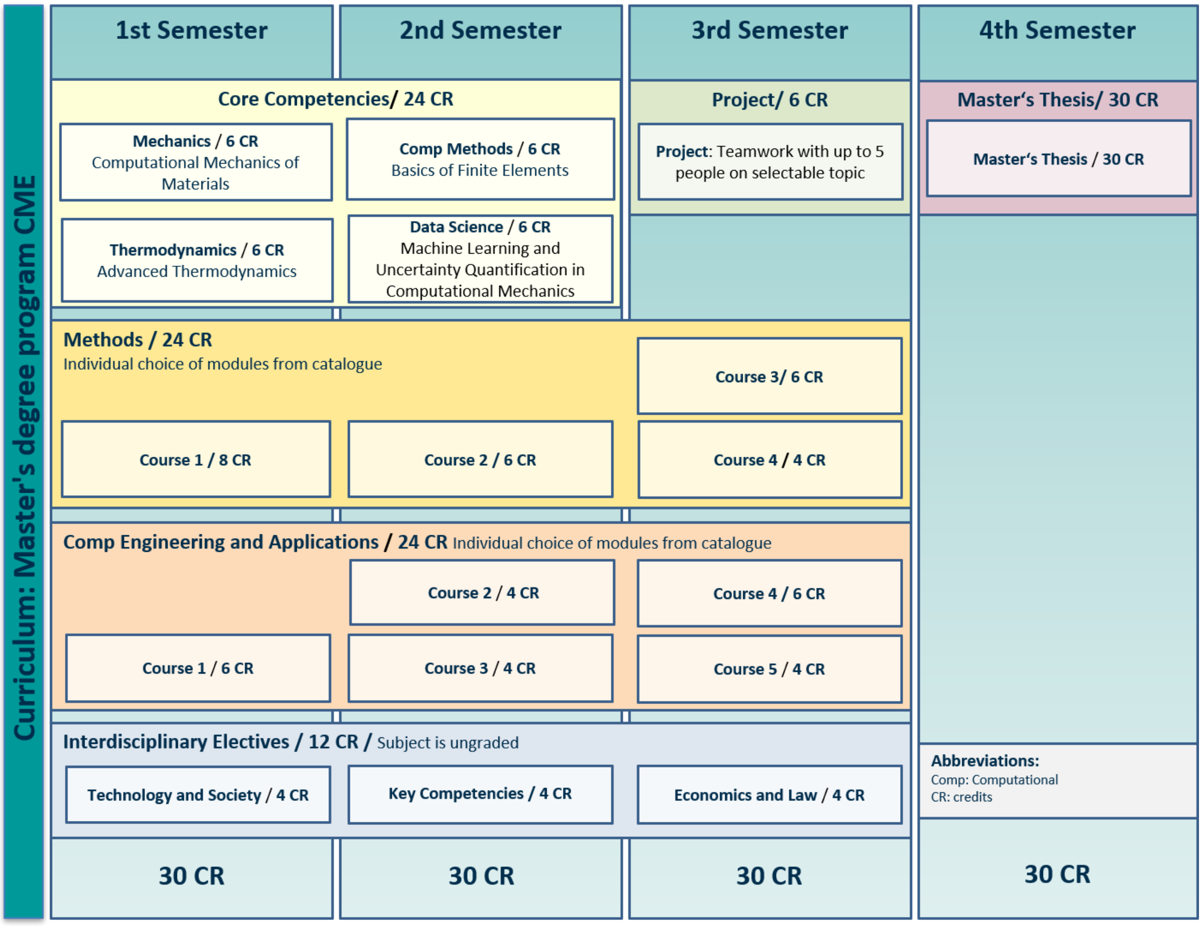
The legal basis for the study program and the exmaminations is the „Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang
Computaional Modeling in Engineering“ (Study and Examination Regulations of the Karlsruhe Institute of Technology (KIT) for the Master Course of Studies in Computational Modeling in Engineering) dated 26 February 2026

German Version

English Version (Not legally binding)

2 Curriculum

This is a graphical representation of the study plan explained in 1.2.



3 Study Program Structure

Mandatory	
Master's Thesis	**30 CP**
Core Competencies	**24 CP**
Methods	**24 CP**
Computational Engineering and Applications	**24 CP**
Project	**6 CP**
Interdisciplinary Electives ***This field will not influence the calculated grade of its parent.***	**12 CP**

3.1 Master's Thesis

Credits
30

ID	Name	Language	Term offered	Credits
Mandatory				
M-MACH-106969	Master's Thesis	**EN**	**WT+ST**	**30 CP**

3.2 Core Competencies

Credits
24

ID	Name	Language	Term offered	Credits
Mandatory				
M-MACH-106947	Mechanics	**EN**	**WT**	**6 CP**
M-CIWVT-106964	Thermodynamics	**EN**	**WT**	**6 CP**
M-BGU-107079	Computational Methods	**EN**	**ST**	**6 CP**
M-BGU-107080	Data Science	**EN**	**ST**	**6 CP**

3.3 Methods

Credits
24

ID	Name	Language	Term offered	Credits
Methods (Elective: at least 24 credits)				
M-MACH-107094	Computational Elasticity	**EN**	**WT**	**6 CP**
M-MACH-107450	Data and Artificial Intelligence for Numerical Simulations	**EN**	**ST**	**4 CP**
M-MACH-107088	Deep Learning for Engineers	**EN**	**ST**	**6 CP**
M-MACH-107850	Heat and Mass Transfer	**EN**	**ST**	**4 CP**
M-MACH-107485	Introduction to Multi-Body Dynamics	**EN**	**WT**	**8 CP**
M-MACH-107687	Mathematical Methods in Fluid Mechanics	**DE/EN**	**WT**	**6 CP**
M-MACH-107110	Nonlinear Continuum Mechanics	**EN**	**ST**	**8 CP**
M-MACH-107459	Phase-Field Method in Thermomechanics	**EN**	**ST**	**4 CP**
M-MACH-107613	Probabilistic Measurement and Estimation	**EN**	**ST**	**6 CP**
M-MACH-107108	Theory of Stability	**EN**	**ST**	**6 CP**
M-CIWVT-106715	Advanced Methods in Nonlinear Process Control	**EN**	**ST**	**4 CP**
M-CIWVT-106319	Data-Based Modeling and Control	**EN**	**WT**	**6 CP**
M-CIWVT-106320	Estimator and Observer Design	**EN**	**WT**	**6 CP**
M-CIWVT-106676	Introduction to Numerical Simulation of Reacting Flows	**EN**	**WT**	**8 CP**
M-CIWVT-106832	Model Development and Simulation in Thermal Process Engineering	**DE**	**WT**	**6 CP**
M-CIWVT-106316	Nonlinear Process Control	**EN**	**WT**	**6 CP**
M-CIWVT-107076	Numerical Simulation of Reacting Multiphase Flows	**EN**	**ST**	**8 CP**
M-CIWVT-106317	Optimal and Model Predictive Control	**EN**	**ST**	**6 CP**
M-CIWVT-107781	Polymer Thermodynamics	**EN**	**WT**	**6 CP**
M-CIWVT-106313	Principles of Constrained Static Optimization	**EN**	**WT**	**4 CP**
M-CIWVT-107779	Statistical Thermodynamics	**EN**	**ST**	**6 CP**
M-CIWVT-107039	Thermal Process Engineering II	**DE**	**ST**	**6 CP**
M-CIWVT-107780	Thermodynamics of Interfaces	**EN**	**ST**	**6 CP**
M-BGU-103384	Advanced Computational Fluid Dynamics	**EN**	**ST**	**6 CP**
M-BGU-107859	Computational Contact Mechanics	**EN**	**ST**	**6 CP**
M-BGU-107858	Computational Structural Dynamics	**EN**	**ST**	**6 CP**
M-BGU-107857	Finite Elements in Solid Mechanics	**EN**	**WT**	**6 CP**
M-BGU-107860	Fracture and Damage Mechanics	**EN**	**WT**	**6 CP**
M-BGU-103375	Numerical Fluid Mechanics	**EN**	**WT**	**6 CP**
M-BGU-107916	Wave Propagation in Solids	**EN**	**ST**	**4 CP**
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab	**DE/EN**	**ST**	**4 CP**
M-MATH-101338	Parallel Computing	**DE/EN**	**Irreg.**	**6 CP**
M-ETIT-106953	Cyber-Physical Modeling	**EN**	**ST**	**6 CP**
M-ETIT-107497	Optimal Control	**EN**	**WT**	**6 CP**

3.4 Computational Engineering and Applications

Credits
24

ID	Name	Language	Term offered	Credits
Computational Engineering and Applications (Elective: at least 24 credits)				
M-MACH-107094	Computational Elasticity	**EN**	**WT**	**6 CP**
M-MACH-107095	Computational Inelasticity	**EN**	**ST**	**6 CP**
M-MACH-107100	Machine Dynamics II	**EN**	**WT**	**4 CP**
M-MACH-107102	Modeling of Polymer and Suspension Flows for Industrial Manufacturing Processes	**EN**	**ST**	**4 CP**
M-MACH-107851	Numerical Methods for Engineering Applications	**EN**	**ST**	**4 CP**
M-MACH-107731	Particle Dynamics and Atomistic Simulation	**EN**	**ST**	**4 CP**
M-CIWVT-106809	Computer-Aided Reactor Design	**DE**	**WT**	**6 CP**
M-CIWVT-106319	Data-Based Modeling and Control	**EN**	**WT**	**6 CP**
M-CIWVT-106320	Estimator and Observer Design	**EN**	**WT**	**6 CP**
M-CIWVT-106676	Introduction to Numerical Simulation of Reacting Flows	**EN**	**WT**	**8 CP**
M-CIWVT-106316	Nonlinear Process Control	**EN**	**WT**	**6 CP**
M-CIWVT-107076	Numerical Simulation of Reacting Multiphase Flows	**EN**	**ST**	**8 CP**
M-CIWVT-106317	Optimal and Model Predictive Control	**EN**	**ST**	**6 CP**
M-CIWVT-107781	Polymer Thermodynamics	**EN**	**WT**	**6 CP**
M-CIWVT-106313	Principles of Constrained Static Optimization	**EN**	**WT**	**4 CP**
M-CIWVT-106537	Reactor Modeling with CFD	**EN**	**ST**	**6 CP**
M-CIWVT-106965	Simulation of Fluid Separation Processes	**EN**	**ST**	**6 CP**
M-BGU-107859	Computational Contact Mechanics	**EN**	**ST**	**6 CP**
M-BGU-107858	Computational Structural Dynamics	**EN**	**ST**	**6 CP**
M-BGU-107857	Finite Elements in Solid Mechanics	**EN**	**WT**	**6 CP**
M-BGU-105361	Fluid Mechanics of Turbulent Flows	**EN**	**ST**	**6 CP**
M-BGU-107860	Fracture and Damage Mechanics	**EN**	**WT**	**6 CP**
M-BGU-105362	Modeling of Turbulent Flows - RANS and LES	**EN**	**WT**	**6 CP**
M-BGU-107828	Multiscale and Multiphysics Modeling for Porous Building Materials	**EN**	**ST**	**6 CP**
M-BGU-107916	Wave Propagation in Solids	**EN**	**ST**	**4 CP**
M-ETIT-106953	Cyber-Physical Modeling	**EN**	**ST**	**6 CP**
M-ETIT-106690	Digital Real Time Simulations for Energy Technologies	**EN**	**ST**	**3 CP**
M-ETIT-107515	Multivariable Control Systems	**EN**	**WT**	**6 CP**
M-ETIT-107644	Nonlinear Control Systems	**EN**	**ST**	**6 CP**
M-ETIT-107524	Robotics, Automation, and Systems Control Lab	**EN**	**ST**	**6 CP**
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab	**DE/EN**	**ST**	**4 CP**
M-MATH-101338	Parallel Computing	**DE/EN**	**Irreg.**	**6 CP**

3.5 Project

Credits
6

ID	Name	Language	Term offered	Credits
Mandatory				
M-MACH-106948	Project	**EN**	**WT+ST**	**6 CP**

3.6 Interdisciplinary Electives

Credits
12

ID	Name	Language	Term offered	Credits
Mandatory				
M-MACH-106944	Technology and Society	**EN**	**WT+ST**	**4 CP**
M-MACH-106945	Key Competencies	**EN**	**WT+ST**	**4 CP**
M-MACH-106946	Economics and Law	**EN**	**WT+ST**	**4 CP**

4 Modules

M 4.1 Module: Model Development and Simulation in Thermal Process Engineering [M-CIWVT-106832]

Coordinators: Prof. Dr.-Ing. Tim Zeiner
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-113702	Model Development and Simulation in Thermal Process Engineering		**6 CP**	**Zeiner**

Assessment
Learning control is an examination of another type. Presentation of project results.

Prerequisites
None

Module Grade Calculation
The module grade is the grade of the examination of another type.

Workload

- Attendance time: Lectures and Exercises 6o hrs
- Self-study: 60 hrs
- preperation presentation: 60 hrs

Recommendations
Thermodynamics III

M 4.2 Module: Advanced Computational Fluid Dynamics [M-BGU-103384]

Coordinators: Prof. Dr.-Ing. Markus Uhlmann
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	5	3

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-106769	Parallel Programming Techniques for Engineering	WT+ST	3 CP	Uhlmann
T-BGU-106768	Numerical Fluid Mechanics II	WT+ST	3 CP	Uhlmann

Assessment
- module component T-BGU-106768 with oral examination according to § 4 Par. 2 No. 2
- module component T-BGU-106769 with oral examination according to § 4 Par. 2 No. 2

details about the learning controls, see module components

Prerequisites
module 'Numerical Fluid Mechanics' must be completed

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-BGU-103375 - Numerical Fluid Mechanics must have been passed.

Competence Goal
Students are able to numerically solve simplified flow problems based upon the Navier-Stokes equations in an independent fashion. This involves the design of a solution method, the analysis of its properties (concerning stability, precision, computational effort), the algorithmic implementation, the validation with respect to appropriate test cases, and the final documentation of the results. Furthermore, participants of this course are enabled to judge techniques for the use of massively parallel computer systems to solve fluid mechanics problems as to their efficiency and applicability. They are capable of applying the appropriate parallel programming techniques to selected model problems.

Content
In the present module, advanced skills in the numerical solution of fluid mechanics problems are imparted, building upon the material of the course Numerical Fluid Mechanics I. Here, various numerical solution methods for the time-dependent Navier-Stokes equations in several spatial dimensions are demonstrated with the aid of practical examples. This includes the following aspects: coupling and decoupling of velocity and pressure fields in incompressible flows, numerical treatment of discontinuities (shock waves, hydraulic jumps), computation of scalar transport, numerical tracking of inertial particles, linear stability analysis.

The course Parallel Programing Techniques for Engineering Problems conveys the fundamental programming concepts for massively-parallel computer systems. First, the common parallel computer architectures and the most widely used programming paradigms are introduced. Then techniques for implementing standard algorithms of numerical fluid mechanics (and other disciplines involving field problems) are presented, analyzed and practiced with the aid of the Message Passing Interface (MPI) standard.

Module Grade Calculation
grade of the module is CP weighted average of grades of the partial exams

Additional Information
none

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- Parallel Programming Techniques for Engineering Problems lecture, exercise: 30 h
- Numerical Fluid Mechanics II lecture, exercise: 30 h

independent study:

- preparation and follow-up lectures, exercises Parallel Programming Techniques for Engineering Problems: 30 h
- examination preparation Parallel Programming Techniques for Engineering Problems (partial examination): 30 h
- preparation and follow-up lectures, exercises Numerical Fluid Mechanics II: 30 h
- examination preparation Numerical Fluid Mechanics II (partial examination): 30 h

total: 180 h

Recommendations
Programing skills in at least one compiler language (C,C++, FORTRAN or equivalent)

Literature
C. Hirsch “Numerical computation of internal and external flows” Butterworth-Heinemann, 2nd edition, 2007.
J.H. Ferziger and M. Peric “Computational Methods for Fluid Dynamics”, Springer, 3rd edition, 2001.
N. Carriero “How to Write Parallel Programs: A First Course”, MIT Press, 1990.
T.G. Mattson, B.A. Sanders, B.L. Massingill “Patterns for Parallel Programming” Addison-Wesley, 2004.
M. Snir, S. Otto, S. Huss-Lederman, D. Walker, J. Dongarra “MPI: The Complete Reference”, MIT Press, 1995.

4.3 Module: Advanced Methods in Nonlinear Process Control [M-CIWVT-106715]

Coordinators: Dr.-Ing. Pascal Jerono
Prof. Dr.-Ing. Thomas Meurer
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-113490	Advanced Methods in Nonlinear Process Control	**ST**	**4 CP**	**Jerono, Meurer**

Assessment
The learning control is an oral exam lasting approx. 45 minutes.

Prerequisites
None

Competence Goal
Students have an in-depth understanding of methods and concepts for the analysis and the control of nonlinear dynamic systems. They understand the underlying mathematical concepts and can apply them to new problems. They are able to independently design non-linear controls for specific problems and analyze the stability of the closed-loop system.

Content
The module covers selected advanced methods in nonlinear control of finite-dimensional systems that directly exploit the nonlinear system dynamics and result in control concepts relevant for different applications. This includes in particular:

- Lyapunov theory and Lyapunov-based design methods
- Disspativity and passivity-based control concepts
- Input-to-state stability

Problem sets are considered in the exercises to apply the developed methods using analytical tools as well as computer algebra systems to realize the design approaches.

Module Grade Calculation
The module grade ist the grade of the oral exam.

Workload

- Attendance time: Lecture 30 hrs
- Homework: 30 hrs
- Exam preparation: 60 hrs

Literature

- T. Meurer, P. Jerono: Advanced Methods in Nonlinear Control, Lecture Notes.
- T. Meurer: Nonlinear Process Control, Lecture Notes.
- B. Brogliato, R. Lozano, B. Maschke, O. Egeland: Dissipative systems analysis and control, Springer, 2007.
- H.K. Khalil: Nonlinear Systems, Prentice Hall, 2002.
- M. Krstic, I. Kanellakopoulos, P. Kokotovic: Nonlinear and Adaptive Control Design, John Wiley & Sons, 1995.
- R. Sepulchre, M. Jankovic, P.V. Kokotovic: Constructive Nonlinear Control, Springer-Verlag, 1997.
- A.J. van der Schaft: L2-gain and passivity techniques in nonlinear control, Springer, 2016.
- M. Vidyasagar: Nonlinear Systems Analysis, SIAM, 2002.

M 4.4 Module: Computational Contact Mechanics [M-BGU-107859]

Coordinators: Dr.-Ing. Marlon Franke
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-115276	Computational Contact Mechanics	**WT+ST**	**6 CP**	**Franke**

Assessment
- module component T-BGU-115276 with oral examination according to § 4 Par. 2 No. 2

details about the learning control, see module component

Prerequisites
none

Competence Goal
The students gain the ability to name the basics for the numerical simulation of contact problems. They can transfer these capabilities to the discussion of deformable bodies in contact. The students can describe the handling of general interface problems, non-smooth dynamics and inequality constraints. The students are able to apply formulations of interfaces based on collocation methods and recent integral formulations.

Content
The continuum mechanical description of deformable bodies (continua) with second-order condition is imparted. The formulation of contact conditions and friction laws is discussed. Further, methods for claiming of constraints is discussed. The contact contribution is emphasised particularly by the subsequent numerical implementation.

Module Grade Calculation
grade of the module is grade of the exam

Additional Information
The module will be offered newly as from winter term 2026/27 in English.

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- lecture, exercise: 60 h

independent study:

- preparation and follow-up lectures, exercises: 45 h
- examination preparation: 75 h

total: 180 h

Recommendations
course Introduction to Continuum Mechanics (6200421), module 'Basics of Finite Elements'

Literature
[1] Laursen: Computational Contact and Impact Mechanics
[2] Wriggers: Computational Contact Mechanics

4.5 Module: Computational Elasticity [M-MACH-107094]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-113989	Computational Elasticity	**WT**	**5 CP**	**Böhlke, Langhoff**
T-MACH-114529	Tutorial Computational Elasticity	**WT**	**1 CP**	**Böhlke, Langhoff**

Assessment
see course

Prerequisites
none

Competence Goal
Upon successful completion of this module, the students can

- analyse and evaluate different methods for solving linear systems of equations
- list and assess basics and assumptions of linear elasticity
- list methods for solving the boundary value problem of linear elasticity
- analyse the different aspects and steps of the finite element method
- write source code for the different steps of the finite element method

Content

- numerical solution of linear systems
- boundary value problems of linear elasticity
- solution methods of the boundary value problem of linear elasticity
- finite-element-technology for linear static problems

Module Grade Calculation
The module grade corresponds to the weighted average of the courses according to the explicit data.

Additional Information
In agreement with the participants, German may also be used as the language of instruction for the course

Workload
Total: 180 hours, of which 45 hours attendance, 135 hours self-study

Recommendations

- Good knowledge in continuum mechanics is necessary
- Basic knowledge of the finite element method is necessary

Teaching and Learning Methods
Lecture, tutorial, computer tutorial

4.6 Module: Computational Fluid Dynamics and Simulation Lab [M-MATH-106634]

Coordinators: PD Dr. Mathias Krause
Organisation: KIT Department of Mathematics
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	German/English	4	3

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MATH-113373	Computational Fluid Dynamics and Simulation Lab		**4 CP**	**Frank, Krause, Simonis, Thäter**

Assessment
For their final project, students prepare a written report, usually 10-15 pages long, which is graded.

Prerequisites
none

Competence Goal
Students are able to jointly model problems beyond their own discipline and simulate them on high-performance computers. They have acquired a critical distance to results and their presentation. They can defend the results of projects in disputes. They have understood the importance of stability, convergence and parallelism of numerical methods from their own experience and are able to evaluate errors in modeling, approximation, computing and presentation.

Content
Lecture part: Introduction to modeling and simulations, introduction to associated numerical methods, introduction to associated software and high-performance computer hardware

Own group work: Working on 1-2 projects in which modelling, discretization, simulation and evaluation (e.g. visualization) are carried out for specific topics from the catalog. The catalog includes e.g: Diffusion processes, turbulent flows, multiphase flows, reactive flows, particle dynamics, optimal control and optimization under constraints, stabilization methods for advection-dominated transport problems.

Module Grade Calculation
The module grade is the grade of the final project.

Workload
Total workload: 120 hours

Attendance: 60 hours

- lectures and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- work on projects and report,
- literature study and internet research relating to the course content

Recommendations
Basic knowledge of the analysis of boundary value problems and of numerical methods for differential equations is recommended. Knowledge of a programming language is strongly recommened.

Teaching and Learning Methods
Lecture + project-oriented Practical Course (2 +2 weekly contact hours)

4.7 Module: Computational Inelasticity [M-MACH-107095]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-113990	Computational Inelasticity	**ST**	**5 CP**	**Böhlke, Langhoff**
T-MACH-114530	Tutorial Computational Inelasticity	**ST**	**1 CP**	**Böhlke, Langhoff**

Assessment
see courses

Prerequisites
none

Competence Goal
Upon successful completion of this module the students

- apply and evaluate algorithms for solving non-linear equations and systems of equations
- compute stresses and strains in the framework of infinitesimal plasticity
- apply and assess models of generalized standard materials
- list and analyse fundamental equations of advanced material theories
- write source code for material routines to be used within commercial FE-codes

Content

- numerics of nonlinear systems
- balance equations of geometrically nonlinear solid mechanics
- infinitesimal plasicity
- linear and gemetrically nonlinear thermoelasticity

Module Grade Calculation
The module grade corresponds to the weighted average of the courses according to the explicit data.

Workload
Total: 180 hours, of which 45 hours attendance, 135 hours self-study

Teaching and Learning Methods
Lecture, tutorial, computer tutorial

M 4.8 Module: Computational Methods [M-BGU-107079]

Coordinators: Prof. Dr.-Ing. Peter Betsch
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Core Competencies

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-115272	Homework 'Basics of Finite Elements'	**ST**	**1 CP**	**Betsch**
T-BGU-115273	Basics of Finite Elements	**WT+ST**	**5 CP**	**Betsch**

Assessment
- module component T-BGU-115272 with not graded coursework according to § 4 Par. 3
- module component T-BGU-115273 with oral examination according to § 4 Par. 2 No. 2

details about the learning controls, see module components

Prerequisites
none

Competence Goal
The students can describe the structure and the functionality of FE codes. They can formulate the basics of variational principles of FEM as well as the Lagrangian element family of different order of projection for one-dimensional, planar and spatial problems in the fields of linear strength of materials and heat transport. They know, that it is an approximate solution method for boundary value problems, and they are aware of its limits. They can get familiar quickly with commercial FE codes and can use them reasonably.

Content
The theoretical principles as well as the numerical implementation of Finite Element Methods are covered. The major terms are discussed such as weak form of the boundary value problem, test function, projection function, continuity requirements, domain discretization, Galerkin approximation, stiffness matrix, assembly,iso-parametric concept, numerical integration and accuracy of finite element approximation.

Module Grade Calculation
Module grade is the grade of the exam

Additional Information
none

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- lecture, exercise: 60 h

independent study:

- preparation and follow-up lectures, exercises: 45 h
- processing exercises sheets (not graded coursework): 30 h
- examination preparation: 45 h

total: 180 h

Recommendations
none

Literature
[1] Cook, Malkus, Plesha: Concept and Applications of Finite Element Analysis, 1989.
[2] Hughes: The Finite Element Method, 1987.
[3] Zienkiewicz, Taylor: The Finite Element Method, Volume 1,2 & 3, 2000.
[4] Bathe: Finite-Elemente-Methoden, 2001.

M 4.9 Module: Computational Structural Dynamics [M-BGU-107858]

Coordinators: Prof. Dr.-Ing. Peter Betsch
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-115275	Computational Structural Dynamics	**WT+ST**	**6 CP**	**Betsch**

Assessment
- module component T-BGU-115275 with oral examination according to § 4 Par. 2 No. 2

details about the learning control, see module component

Prerequisites
none

Competence Goal
Students can classify common time-step methods in structural dynamics and are able to select appropriate integrators for specific applications. They can explain fundamental methods for evaluating the properties of time-step methods, particularly with regard to accuracy and numerical stability. In addition to the standard methods of linear structural dynamics, they can also formulate methods for constructing structure-preserving integrators for nonlinear structural dynamic systems. They are also able to implement these methods in practice using computers.

Content
First, discrete systems in linear structural dynamics are considered. Common time-step methods for integrating the equations of motion are discussed (e.g., the Newmark method). The Hamiltonian principle and its connection to the Lagrangian and Hamiltonian equations are discussed for discrete mechanical systems. The class of variational integrators is based on a discrete Hamiltonian principle and allows for the systematic construction of numerous integrators. In the context of numerically stable integration of nonlinear systems, the focus is on structure-preserving methods. Using model problems, the programming implementation of selected integrators is carried out within the framework of MATLAB.

Module Grade Calculation
grade of the module is grade of the exam

Additional Information
The module will be offered newly as from winter term 2026/27 in English.

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- lectures, exercises: 60 h

independent study:

- preparation and follow-up: 45 h
- working on programming exercises: 30 h
- examination preparation and examination: 45 h

total: 180 h

Recommendations
module 'Basics of Finite Elements'

M 4.10 Module: Computer-Aided Reactor Design [M-CIWVT-106809]

Coordinators: Dr.-Ing. Martin Kutscherauer
Prof. Dr.-Ing. Gregor Wehinger

Organisation: KIT Department of Chemical and Process Engineering

Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-113667	Computer-Aided Reactor Design		**6 CP**	**Wehinger**

Assessment
Learning control is an examination of another type:
The project assignment will be evaluated based on the source code, the poster, and its presentation.

Prerequisites
None.

Competence Goal
The students are able to:

- describe and apply the mathematical and physical principles of chemical reaction engineering models,
- apply the Python software independently and thoroughly to the reactor models,
- develop a reaction engineering model for an unknown chemical process and solve problems of reactor design,
- analyse and evaluate the results obtained by comparing them with current literature,
- recognise and evaluate errors and uncertainties in the model,
- represent, present and critically discuss the results they have obtained in an appropriate form.

Content

1. Introduction to modeling and simulation of chemical reactors
2. Balance equations of chemical reactors
3. Processes in porous systems
4. Homogeneous and heterogeneous reactor models
5. Applied numerical methods
6. Reactor design

Module Grade Calculation
The module grade ist the grade of the examiation of another type.

Additional Information
Learning control is an examination of another type: The project work is assessed on the basis of the source code, the poster and its presentation.

Workload

- Attendance time: 45 h
- Homework: 105 h
- Exam preparation: 30 h

Recommendations
Knowledge about Chemical Process Engineering I and II is recommended.

Literature

- Finlayson: Introduction to Chemical Engineering Computing; 2012, Wiley
- Jakobsen: Chemical Reactor Modeling; 2014, Springer
- Salmi et al.: Chemical reaction engineering: a computer-aided approach; 2020, de Gruyter

M 4.11 Module: Cyber-Physical Modeling [M-ETIT-106953]

Coordinators: Prof. Dr.-Ing. Mike Barth
Prof. Dr.-Ing. Sören Hohmann

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-ETIT-113908	Cyber-Physical Modeling		**6 CP**	**Barth, Hohmann**

Assessment
The examination takes place in the form of a written examination lasting 90 min.

Prerequisites
none

Competence Goal

- The students are familiar with the concepts of Cyber-Physical System.
- Students understand the need for advanced methods and services in the field of automation.
- Students can validate different information models and ontologies for their applicability in CPS.
- Students will be able to model data, information and knowledge or extract them from existing systems.
- The students know suitable modeling tools and their application.
- The students understand the general model concept as well as the characteristics of physical and data-based modeling and can describe their differences.
- They can structure complex systems and systematically analyze dependencies of subsystems.
- They can explain the general procedure of physical and data-based modeling, apply it to technical systems, and analyze the results.
- They can apply causal and non-causal modeling approaches and distinguish between them.
- Students have gained an understanding of generalized, cross-domain, physical relationships and can develop models for electrical, mechanical, pneumatic and hydraulic systems.
- They can describe the relationship between generalized, cross-domain, physical models and basic procedures of physical-based control and explain their advantages / limitations based on basic knowledge of control engineering.
- The students can estimate and judge the effects of disturbances and real conditions on the identification results.

Content
This course aims at engineering students that focus on a system-based engineering curriculum, including architectures, modeling & simulation for Cyber Physical Systems. The module is designed to teach students the theoretical and practical aspects of Digital Twins and their interconnection with their physical counterpart. It encompasses fundamental topics along the complete process of modeling technical systems. For this purpose, it includes the conception and construction of digital twins including their model components. In terms of modeling and simulation of physical systems, two major areas will be covered: On the one hand, physical-based modeling techniques which derive formal model equations based on analyzing the physical first principles of technical systems. This includes generalized equivalent circuits and variational analysis (Euler-Lagrange of the first kind). On the other hand, data-based identification techniques will be covered which are used to identify concrete model parameters for a given technical system from experimental data sets. When combining the identification with an initial, non-physical, structural set up of model equations, the complete process is often referred to as data-based modeling or black-box modeling. Both modeling areas base on available information about the physical system which is structured in Meta- and Information-Models. Examples that are covered in this lecture are Metamodels, e.g. AutomationML or the asset administration shell principles. Also, semantic web principles and ontologies will be part of the lecture content.

Module Grade Calculation
The module grade is the grade of the written exam.

Workload

1. attendance in lectures an exercise: 3+1 SWS (60 h)
2. pre-/postprocessing of the lecture (90 h)
3. preparation of and attendance in the exam: (30 h)

   A total of 180 h = 6 CR

Recommendations
Interest in Modeling and Simulation of modern Cyber-Physical Systems in combination with concepts of digital twins, system architectures and Co-Simulation.
Sound understanding of engineering mechanics, electrical, mechatronic systems / physics / Software-Engineering should be fulfilled to successfully attend the lecture, exercise tasks / case studies, and exam.

Teaching and Learning Methods
lecture (3 SWS), excercise (1 SWS)

M 4.12 Module: Data and Artificial Intelligence for Numerical Simulations [M-MACH-107450]

Coordinators: Dr. Anastasia August
Dr.-Ing. Arnd Koeppe
Organisation: KIT Department of Mechanical Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-113926	Data and Artificial Intelligence for Numerical Simulations	**ST**	**4 CP**	**August, Koeppe**

Assessment
see individual course

Prerequisites
The course requires a *good foundation in (continuum) mechanics* or *numerical simulations*. **One of the following courses (or equivalent) must be completed successfully**

- Computational Mechanics of Materials [T-MACH-113939]
- Fluid Mechanics of Turbulent Flows [T-BGU-110841]
- Mathematical Methods in Fluid Mechanics [T-MACH-113956]
- Nonlinear Continuum Mechanics [T-MACH-111026]
- Computational Elasticity [T-MACH-113989]
- Computational Inelasticity [T-MACH-113990]

Competence Goal
Students will master advanced data-driven modeling techniques and independently apply AI methods to real-world scientific problems through structured projects and challenges.

Learning Goals

• Students understand advanced methods of data-driven modeling.

• Students can apply AI techniques to scientific data and problems.

• Students work independently on self-organized machine-learning projects.

Content
(*English only*) The course is divided into two main parts, each culminating in a group project. A preliminary tutorial ensures all students have foundational skills in Python and machine learning.

Preliminary Tutorial: Python and Machine Learning Essentials

Objective: Establish a baseline in Python programming and machine learning.

Content: Data handling, basic ML workflows, and tools like scikit-learn and TensorFlow.

Part 1: Generating Structured Simulation Data

Objective: Learn systematic approaches to creating and managing simulation data for physical problems.

Key Topics:

• Data generation strategies for boundary and initial value problems.

• Active learning for efficient data collection.

• Structured data management and automated workflows.

Group Project/Challenge 1: Teams create and document structured datasets for a physical simulation problem.

Part 2: Deep Learning for Field- and Time-Dependent Data

Objective: Apply deep learning to dynamic and spatial data using data-driven and physics-informed approaches.

Key Topics:

• Deep learning models (e.g., CNNs, RNNs, GANs) for simulations.

• Hyperparameter tuning and optimization.

• Combining neural networks with physical laws for interpretability.

Group Project/Challenge 2: Teams develop deep learning models to predict field- or time-dependent behavior in a physical system.

Examination

The course concludes with an oral examination and written reports based on group projects.

Module Grade Calculation
The module grade corresponds to the grade of the examination.

Workload
120 hours (45 in-person, 75 self-study)

Teaching and Learning Methods
• Lectures: In person and via videos/flipped classroom sessions.

• Individual Team Projects: Self-organized group challenges focusing on real-world applications.

• Consultation Hours: Regular mentoring and Q&A sessions.

M 4.13 Module: Data Science [M-BGU-107080]

Coordinators: Prof. Dr.-Ing. Steffen Freitag
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Core Competencies

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-115229	Machine Learning and Uncertainty Quantification in Computational Mechanics	**ST**	**6 CP**	**Freitag, Patel**

Assessment
- module component T-BGU-115229 with examination of another type according to § 4 Par. 2 No. 3

details about the learning control, see module component

Prerequisites
none

Competence Goal
Upon completing the module, students will gain a deeper understanding of machine-learning (ML) and uncertainty-quantification (UQ) methods tailored to computational mechanics and materials modeling with a focus on concrete technology and structural mechanics. The machine learning modulepart enables them to build and deploy end-to-end ML pipelines in Python — covering data acquisition, cleaning, feature engineering, model training, hyper-parameter tuning and production deployment — across a wide range of algorithms, including shallow-learning models, convolutional and recurrent neural networks (CNNs and RNNs), physics-informed neural networks (PINNs) and large-language-model (LLM) APIs. In the UQ part of the module, the students achieve competences in different uncertainty quantification approaches. Beside stochastic approaches also interval and fuzzy approaches and its combination to polymorphic UQ are discussed to deal with aleatory and epistemic uncertainties. The students get competences in performing structural analyses with uncertain data. They are trained to consider uncertain information for the modeling and the computation of structures.

Ultimately, the course equips participants to identify and capitalize on the many digital-innovation opportunities that remain untapped in the field of computational mechanics, materials modelling and structuralengineering practice.

Content

The module is organized into two complementary submodules. The first submodule concentrates on applying modern machine-learning techniques to challenges in computational mechanics, material modeling with a focus on concrete technology and structural mechanics. The second submodule introduces uncertainty-quantification methods for situations in which data are limited or noisy a common challenge when developing new materials, e.g., concrete mixes, designing structures, predicting service life of structures and tackling similar engineering tasks.

Machine Learning in Computational and Structural Mechanics and Material Modelling:

This module component equips both newcomers and experienced students with practical machine-learning skills for computational mechanics, material modeling and structural engineering. It begins with a concise refresher on core concepts such as learning strategy (unsupervised, supervised, reinforcement) and problem types (classification, regression, clustering, recommendations), the difference between shallow and deep models and data types in engineering (images, tables, time series). The course then moves to exploratory, unsupervised techniques such as clustering and principal-component analysis. Classical “shallow” models for regression and classification (linear and regularized methods, decision trees, support-vector machines, ensembles) follow, providing a baseline for engineering tasks. Building on this, neural networks are introduced: multilayer perceptrons for regression, physics-informed neural networks (PINNs) as surrogates for numerical simulations, convolutional neural networks (CNNs) for defect detection in images, and recurrent architectures (RNNs/LSTMs) for forecasting sensor time-series data. The module ends discussion of large language models (LLM) and LLM agent frameworks that automate engineering tasks such as verifying code-compliance clauses or drafting structured inspection reports. Throughout the course example use domain-specific datasets such as experimental data (e.g. nano-indentation, compressive-strength), time series sensor data, image data from structures and numerical simulation outputs. Teaching style combines classical presentation-based lectures with virtual lab consisting of live-coding demonstrations and guided lab ensuring that theoretical knowledge translates directly into robust, real-world skills.

Uncertainty Quantification in Computational and Structural Mechanics and Material Modelling:

In the second module component, uncertainty models are presented for the quantification of uncertain data and the consideration of uncertain model assumptions. Beside random variables, intervals and fuzzy numbers are introduced. The model parameters fit based on statistical and imprecise data is trained. Within the polymorphic UQ concept, probability boxes and fuzzy random variables are presented. Different safety concepts in engineering are presented. For the probabilistic safety assessment of structures, the computation with uncertain numbers is introduced by analytical approaches to show how the failure probability of simple structures is obtained. Beside analytical approximation approaches (first order reliability method), the focus is on numerical approaches (Monte Carlo simulations), which can be applied to more complex structural analyses, e.g., based on the finite element method. To reduce the computation time and the required computational resource, numerically efficient surrogate models based on the ML approaches of the first submodule are applied.

Module Grade Calculation

Grade of the module is grade of the exam.

Additional Information

none

Workload

contact hours (1 HpW = 1 h x 15 weeks):

- Machine Learning in Computational and Structural Mechanics and Materials Modelling lecture/exercise: 30 h
- Uncertainty quantification in Computational and Structural Mechanics and Materials Modelling lecture/exercise: 30 h

independent study:

- preparation and follow-up lecture/exercises Machine Learning in Computational and Structural Mechanics and Materials Modelling: 20 h
- preparation and follow-up lecture/exercises Uncertainty quantification in Computational and Structural Mechanics and Materials Modelling: 20 h
- preparation of projekt report and presentation in groups (examination): 80 h

total: 180 h

Recommendations

prior knowledge of python programming is advantageous but can be acquired during course work

M 4.14 Module: Data-Based Modeling and Control [M-CIWVT-106319]

Coordinators: Prof. Dr.-Ing. Thomas Meurer
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-112827	Data-Based Modeling and Control		**6 CP**	**Meurer**

Assessment
Learning control is an oral examination with a duration of about 45 minutes.

Prerequisites
none

Competence Goal
Students have an in-depth understanding of methods and concepts of data-based modeling and control of dynamic systems, including machine learning techniques and corresponding optimization methods. They understand the underlying mathematical concepts and can apply them to new problems. They are able to apply these methods independently to specific problems and familiarize themselves with further literature on their own.

Content
The module covers basic concepts and fundamentals of data-based approaches for modeling and control design for dynamical systems and processes. Data-based approaches for modeling, also called system identification, are used to identify a mathematical description of the considered system from the available input and output data. Data-based approaches for control design compute the controller without an a priori known model of the system. Extensions to learning-based control are addressed, where in principle machine learning techniques are used to learn a model or a controller for a given system.

Problem sets are considered in the exercises to apply the developed methods.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Attendance time: Lectures: 30 hrs. Exercises: 15 hrs.

Self-study: 75 hrs.

Exam preparation: 60 hrs.

Literature

- T. Meurer: Data-based Modeling and Control, Lecture Notes.
- S.L. Brunton, J.N. Kutz: Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control, Cambridge University Press, 2022.
- D. Bertsekas: Reinforcement Learning and Optimal Control, Athena Scientific, 2019.
- D.H. Owens: Iterative Learning Control, Springer, 2016.
- Various recent publications, which will be discussed in lecture.

M 4.15 Module: Deep Learning for Engineers [M-MACH-107088]

Coordinators: Prof. Dr.-Ing. Christoph Stiller
Organisation: KIT Department of Mechanical Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	2

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-113882	Deep Learning for Engineers	**ST**	**6 CP**	**Stiller**

Assessment
written exam

approx 60 min

Prerequisites
none

Competence Goal
Qualification goals

Students acquire comprehensive knowledge in the field of deep neural networks. They will be able to clearly explain the basic principles and functions of such networks. In addition, they will learn to outline various **alternative architectures** and understand their special features.

Another focus is on the **training methods** and their specific characteristics in order to effectively develop and adapt models.

The skills acquired enable students to independently design, train and practically apply deep neural networks for fundamental technical problems, for example in the areas of

- Machine vision
- vehicle control
- robotics

Finally, they are able to flexibly transfer this knowledge to other fields of application and independently develop innovative solutions.

Content
This module teaches students basic and advanced concepts of deep learning with a particular focus on their application in engineering. Starting with an introduction to neural networks, various architectures are presented, including **multilayer perceptrons (MLP)** and **convolutional neural networks (CNN)**, which are particularly important in image processing.

The course content also includes **backpropagation** as a central training method and **graph-based neural networks (GNN)**, which model complex relationship structures. Modern approaches such as **transformers** and **generative networks** are also covered in order to provide an insight into current research developments.

The module is supplemented by the topic of **reinforcement learning**, which teaches strategies for learning from interactions with the environment. Finally, practical applications are dealt with in order to apply and deepen the methods learned in real engineering projects.

Module Grade Calculation
Module grade corresponds to the partial performance grade.

Workload
In total 180h:

Attendance time. 45h
Self-study: 135h

Literature
available in ILIAS

M 4.16 Module: Digital Real Time Simulations for Energy Technologies [M-ETIT-106690]

Coordinators: Prof. Dr.-Ing. Giovanni De Carne
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-ETIT-113449	Digital Real Time Simulations for Energy Technologies		**3 CP**	**De Carne**

Assessment
The examination takes place in form of other types of examination. It consists of an assessment from an exercise on HiL and an oral overall examination (approx. 15 minutes) explaining the exercise results. The overall impression is evaluated.

Prerequisites
none

Competence Goal
To give bachelor's and master's degree students an overview of the need, concept, implementation and execution of Hardware in the Loop (HiL) testing. At the end of the course:

- The students will be able to understand the setup of HiL systems (Device Under Tests, Real Time simulator, I/O, power amps for PHiL, interfacing principles and techniques)
- The students will be able to devise HiL test cases, creating models with an understanding of the trade-off between simulation fidelity and computational resources.
- The students can interface Device Under Tests, running Real Time simulations and executing tests.
- The students are able to perform an independent HiL project and deliver HiL experimental results.

Content
Lesson 1: Introduction

- Overview of control system development process (V-cycle and variants).
- Real-time simulation concept – What does it mean simulating in real time?
- Basic concepts of Real Control Prototyping and Control-Hardware in the Loop.
- Basic concept of Power-HiL

Lesson 2: Introduction to real time simulation (1/2)

- Initial definitions for real time simulations: Wall-clock time, simulation time, hard real-time and soft real-time.
- Off-line simulation software solvers
- Numerical integration, DAE solvers, numerical stability. Complexities induced by switches.
- Distinctions between state-space based and nodal approach-based solvers for CPU
- Difference between CPU and FPGA modeling
- Numerical examples & practical implementation of solvers

Lesson 3: Modelling in real time: grid modelling

- Modeling for HiL, level of model detail vs computational performance
- problems with parallelization due to latencies in transferring data, I/O latency considerations.
- Introducing transmission line decoupling, stublines, ITM and other techniques
- Introducing the State-Space Nodal approach

Lesson 4: Modelling in real time: power electronics

- Modelling components for fast transients (e.g, switches), average models, full switching models
- Interface FPGA-based with CPU-based modelling
- Practical examples and applications

Lesson 5: Modelling in real time: multi-time-scale networks

- Modeling for HiL: different time-scales phasor/RMS, EMT, fast EMT on FPGA.
- Stability issues associated with multi-time-scale hybrid simulation (e.g. RMS/EMT or EMT on CPU and FPGA.
- Multi-time-scale simulation with phasor/EMT/FPGA

Lesson 6: Rapid Control Prototyping (RCP)

- Main Concept and benefits from RCP, Applications
- Generating a code from Simulink and implementation in the real time simulator
- FPGA-based RCP, Datalogging
- Demonstration in classroom

Lesson 7: Controller Hardware In the Loop

- Definition of HIL and testing opportunities
- Analog and digital I/O in real time simulators
- Designing an HiL test – identifying controller functionality to be tested, creating appropriate model and test sequences, identifying potential failures and testing in failure/off-design conditions, use of test automation

Lesson 8: Power Hardware In the Loop

- Introduction to PHIL
- PHIL equipment: power amplifiers. 2Q/4Q applications, specifying power amplifiers
- Interface algorithms between Real Time Simulation and the Device Under Test
- Stability vs. interface accuracy, current state of the art
- Impedance-based stability analysis

Module Grade Calculation
The module grade results of the assessment of an exercise and the oral exam. Details will be given during the lecture.

Workload
The workload includes (2 SWS):

attendance in lectures and exercises: 15*2 h = 30 h
preparation / follow-up: 15*4 h = 60 h
final project, preparation of and attendance in examination: 30 h
A total of 120 h = 4 CR

Recommendations

- Good knowledge of power electronics, linear control theory, and power systems is required.
- Good knowledge of Matlab/Simulink simulation environment is required.

M 4.17 Module: Economics and Law [M-MACH-106946]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering
Part of: Interdisciplinary Electives

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	pass/fail	Each term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Economics and Law (Elective: at least 4 credits)				
T-WIWI-102861	Advanced Game Theory	WT	4 CP	Ehrhart, Puppe, Reiß
T-WIWI-108715	Artificial Intelligence in Service Systems	WT	4 CP	Satzger
T-ETIT-104572	Business Innovation in Optics and Photonics	WT	4 CP	Nahm
T-WIWI-112723	Computational Macroeconomics	ST	4 CP	Brumm
T-WIWI-102864	Entrepreneurship	WT+ST	4 CP	Terzidis
T-MACH-114176	Human Factors Engineering II (Organizational Design)	WT	4 CP	Deml
T-MACH-115056	Quality Management	WT	4 CP	Lanza

Assessment
Depending on individual choice.

Prerequisites
none

Competence Goal
Students 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
depending on individual choice

Workload
The workload is approx. 120 hours, which corresponds to 4 CP.

For a course of 2 SWS (90 minutes per week), this corresponds to 30 hours of attendance and 90 hours of independent study.

Teaching and Learning Methods
lectures, lab courses.

M 4.18 Module: Estimator and Observer Design [M-CIWVT-106320]

Coordinators: Dr.-Ing. Pascal Jerono
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-112828	Estimator and Observer Design		**6 CP**	**Jerono**

Assessment
Learning control is an oral examination with a duration of about 45 minutes.

Competence Goal
Students will gain an in-depth understanding of the concepts and methods used to estimate and identify the state of dynamic systems and will be familiar with their advantages and disadvantages. In addition, students will be able to analyze the observability and detectability properties of the underlying system dynamics and use this information to design suitable state observers for practical applications. Students are familiar with various numerical solution approaches, understand how they work, and can implement them for estimation and observer design tasks.

Content
State feedback control relies on the availability of the full state vector, which is in general not available from measurements. Moreover determining the states (or parameters) of a dynamical systems is of interest on its own as this allows to obtain insights into the system dynamics or to estimate quantities that are not or hardly measurable. The lecture addresses basic concepts of estimation and identification methods and the design of optimal state observers for linear and nonlinear dynamical systems both in a continuous and a discrete time setting. This includes:

- Introduction to fundamental concepts for system identification and state estimation
- State-space approaches for system identification
- Analysis of observability and detectability
- Design of linear and nonlinear observers as well as optimal state estimators (Kalman-Bucy and Kalman Filters)
- Numerical methods

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Attendance time: Lectures: 30 hrs. Exercises: 15 hrs.

Self-study: 60 hrs.

Exam preparation: 75 hrs.

Literature

- P. Jerono: Estimator and Observer Design, Lecture Notes.
- L. Lennart: System identification. Birkhäuser, 1998.
- H. Nijmeijer, A. Van der Schaft: Nonlinear dynamical control systems, Springer-Verlag, 1990.
- Isidori: Nonlinear Control Systems, Springer-Verlag, 1995.
- Gelb: Applied optimal estimation. MIT Press, 1974.
- F.L. Lewis, X. Lihua, and D. Popa: Optimal and robust estimation: with an introduction to stochastic control theory, CRC Press, 2017.

M 4.19 Module: Finite Elements in Solid Mechanics [M-BGU-107857]

Coordinators: Prof. Dr.-Ing. Peter Betsch
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-115274	Finite Elements in Solid Mechanics	WT+ST	6 CP	Betsch

Assessment
- module component T-BGU-115274 with oral examination according to § 4 Par. 2 No. 2

details about the learning control, see module component

Prerequisites
none

Competence Goal
Students are able to distinguish and classify mixed finite elements. They are familiar with the underlying multi-field formulations and variational principles. They have a thorough understanding of the continuum mechanics fundamentals of mixed-element formulations and, in addition to linear theory, are familiar with handling geometric and material nonlinearities. They can assess which type of mixed-element formulation is best suited for specific applications. In addition, they gain insight into the practical implementation of these methods.

Content
Building on displacement-based finite elements, this section discusses mixed extensions that are based, among other things, on additional approaches for strains and stresses. The corresponding multi-field variational formulations are first discussed within the framework of linear continuum mechanics, and the connection to variational principles is explained. In particular, the variational principles of Hu-Washizu and Hellinger-Reissner are discussed here. Subsequently, the extension to geometrically and materially nonlinear problems is carried out. Common types of mixed elements are discussed. Examples include the EAS (“Enhanced Assumed Strain”) elements and the Pian-Sumihara-type hybrid elements. In particular, the course demonstrates when the use of each element formulation is advantageous. In addition to the theoretical foundations, the practical implementation of mixed elements in a finite element program is also covered. As part of this, students are expected to complete independent implementation tasks using MATLAB.

Module Grade Calculation
grade of the module is grade of the exam

Additional Information
Module will be offered newly as from winter term 2026/27 in English.

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- lectures, exercises: 60 h

independent study:

- preparation and follow-up: 45 h
- working on programming exercises: 30 h
- examination preparation and examination: 45 h

total: 180 h

Recommendations
module Basics of Finite Elements

M 4.20 Module: Fluid Mechanics of Turbulent Flows [M-BGU-105361]

Coordinators: Prof. Dr.-Ing. Markus Uhlmann
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-110841	Fluid Mechanics of Turbulent Flows	**WT+ST**	**6 CP**	**Uhlmann**

Assessment
- module component T-BGU-110841 with oral examination according to § 4 Par. 2 No. 2

details about the learning control, see module component

Prerequisites
none

Competence Goal
Participants are able to describe the characteristics of turbulent flows, and to quantify their effect upon the transport rates of momentum, heat and mass. They are aware of the problems associated with computationally determining turbulent flow quantities. With this knowledge, they are able to weigh the prosand cons of the different modeling approaches; they are further able to choose an appropriate approach for a given application.

Content
The mathematical description of the physics of turbulence is successively developed. The module presents the phenomenology of turbulent flows, introduces the statistical description of turbulent flow processes, discusses the characteristics of free and wall-bounded shear flows, and presents an analysis of the turbulent energy cascade.

Module Grade Calculation
grade of the module is grade of the exam

Additional Information
none

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- lecture, exercise: 60 h

independent study:

- preparation and follow-up lectures, exercises: 60 h
- examination preparation: 60 h

total: 180 h

Recommendations
basic fluid mechanics (experience in working with the Navier-Stokes equations)
mathematics (analysis – partial differential equations, Fourier series, vectors/tensors, matrices and eigenvalues; statistics)
knowledge in programming with Matlab is recommended; otherwise it is strongly recommended to participate in the course ’Introduction to Matlab’.

M 4.21 Module: Fracture and Damage Mechanics [M-BGU-107860]

Coordinators: Prof. Dr.-Ing. Thomas Seelig
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-115277	Fracture and Damage Mechanics	**WT+ST**	**6 CP**	**Seelig**

Assessment
- module component T-BGU-115277 with oral examination according to § 4 Par. 2 No. 2

details about the learning control, see module component

Prerequisites
none

Competence Goal
The students are able to apply the principles and methods of fracture mechanics as used for the analysis of structures containing cracks. They are familiar with the basic concepts of damage mechanics and its use in the modeling of complex material behavior. They can establish relationships between continuum mechanical descriptions and material specific aspects.

Content

- phenomenology and mechanisms of fracture
- linear elastic fracture mechanics (crack tip fields, K-concept, energy balance, J-integral, small scale yielding)
- elastic plastic fracture mechanics (Dugdale model, HRR-field, J-controlled crack growth)
- dynamic fracture mechanics (dynamic loading, fast running cracks)
- damage mechanics (mechanisms of brittle and ductile damage, micromechanical and phenomenological models, softening and localization)

Module Grade Calculation
grade of the module is grade of the exam

Additional Information
The module will be offered newly as from winter term 2026/27 in English.

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- lecture, exercise: 60 h

independent study:

- preparation and follow-up lectures, exercises: 60 h
- examination preparation: 60 h

total: 180 h

Recommendations
prior knowledge of basics of continuum mechanics

Literature

Anderson, T.L.: Fracture Mechanics - Fundamentals and Application. CRC Press, 1995

Gdoutos, E.E.: Fracture Mechanics - An Introduction. Kluwer Acad. Publ., 1993

Gross, D., Seelig, Th: Fracture Mechanics - With an Introduction to Micromechanics, Springer, 2018

Krajcinovic, D.: Damage Mechanics. Elsevier, 1996

Kuna, M.: Finte Elements in Fracture Mechanics. Springer, 2013

Sun, C.T., Jin, Z.-H.: Fracture Mechanics. Elsevier, 2012

Zehnder, A.T.: Fracture Mechanics. Springer, 2012

4.22 Module: Heat and Mass Transfer [M-MACH-107850]

Coordinators: Prof. Dr. Dr. Michael Fischlschweiger
Organisation: KIT Department of Electrical Engineering and Information Technology
KIT Department of Mechanical Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-114099	Heat and Mass Transfer	**ST**	**4 CP**	**Fischlschweiger, Yu**

Assessment
written exam

Competence Goal
Students understand and can explain the fundamental mechanisms governing heat and mass transfer, including heat conduction, diffusion, convective heat and mass transfer, phase-change processes, and thermal radiation. Students can derive, formulate, and analyze the governing equations describing heat and mass transfer processes based on the principles of conservation of mass, momentum, species mass and energy. Students can apply analytical solution methods to evaluate transport phenomena in representative engineering systems and correctly interpret the physical meaning of the obtained results. Furthermore, students can formulate mathematical models for heat and mass transfer problems, identify appropriate simplifying assumptions, and assess the validity and limitations of analytical approaches. Students can distinguish between different transport mechanisms, evaluate their relative importance in practical engineering applications. For more complex transport problems, students acquire a fundamental understanding of numerical modelling approaches. They develop the ability to choose modelling strategies according to the physical characteristics and complexity of engineering problems and to critically evaluate the accuracy, applicability, and limitations of analytical and numerical solutions.

Content

- Steady and unsteady heat transfer in homogenous materials; Plates, pipe sections and sperical shells
- Molecular diffusion in gases; analogies between heat conduction and mass diffusion
- Convective, forced heat transfer in pipes/channels and around plates and profiles
- Convective mass transfer, heat-/mass transfer analogy
- Multi phase convective heat transfer (ceondensation, evaporation)
- Radiative heat transfer

Module Grade Calculation

result of examination

Workload
120h

Literature

- 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

M 4.23 Module: Introduction to Multi-Body Dynamics [M-MACH-107485]

Coordinators: Prof. Dr.-Ing. Alexander Fidlin
Organisation: KIT Department of Mechanical Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-114755	Introduction to Multi-Body Dynamics	**ST**	**8 CP**	**Fidlin**

Assessment
see module compoenent

Prerequisites
see module compoenent

Competence Goal
Students are able to
- Describe the kinematics of multibody systems in a standardized mathematical way
- Analyze the structure of multibody systems including holonomic and non-holonomic bonds
- Analyze dynamic behavior using suitable numerical methods
- Recognize and analyze correlations and independently answer technically relevant questions
- Verify, graphically represent and discuss results

Content
1. Kinematics of the rigid body

- Orientation of reference systems
- Reference systems moving relative to each other

2. Dynamics of a rigid body

- Fundamental theorems of mechanics
- Inertia properties of a rigid body
- Equations of motion

3. Mass point systems

- Classification of bonds
- Kinematics of holonomic mass point systems
- Kinetics of holonomic mass point systems
- Kinematics of non-holonomic mass point systems
- Kinetics of non-holonomic mass point systems
- Principle of Jourdain / Kanes formalism

4. Rigid-body systems

- Kinematics of rigid-body systems
- Principle of Jourdain / Kanes formalism

5. Numerical solution methods

- Integration of systems of ordinary differential equations
- Integration of differential- algebraic systems of equations

6. Open systems with chain or tree structure

- Topology of open multibody systems
- Joints in multibody systems
- Kinematics of open multibody systems
- Kinetics of open multibody systems
- Recursive solution of the equations of motion

Module Grade Calculation
The module grade corresponds to the grade of the written exam.

Workload
Approx. 240 hours (90 contact hours and 150 hours of independent study, including class preparation, follow-up work, and exam preparation).

Teaching and Learning Methods
Lecture

M 4.24 Module: Introduction to Numerical Simulation of Reacting Flows [M-CIWVT-106676]

Coordinators: Prof. Dr. Oliver Thomas Stein
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each winter term	1 term	English	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-113435	Introduction to Numerical Simulation of Reacting Flows - Prerequisite		5 CP	Stein
T-CIWVT-113436	Introduction to Numerical Simulation of Reacting Flows		3 CP	Stein

Assessment
The learning control consists of two partial achievements:

1. Completed Coursework: As a prerequisite for the oral exam, reports on the tutorial have to be submitted. These document the processed task, the generated data and their analysis.
2. Oral examination lasting approx. 30 minutes.

Prerequisites
None

Competence Goal
Course participants know the fundamentals of both batch and flow reactors for the simulation of chemical kinetics and reacting flows. They are knowledgeable of numerical methods for temporal and spatial discretisation. In the related Python tutorials, they have obtained a first practical experience in setting up, running and post-processing chemical kinetics and reacting flow simulations, forming the basis for more advanced simulations.

Content

- Introduction to Python
- batch reactors for chemical kinetics simulations
- simple flow reactors
- Newton-Raphson method
- time and space discretisation

Module Grade Calculation
The module grade ist the grade of the oral exam.

Additional Information
The Python tutorials will be conducted on the students' laptops.

Workload

- Attendance time
  Lectures 2 SWS: 30 hrs
  Tutorials 2 SWS: 30 hrs
- Self-study
  Preparation and wrap-up lectures: 15 hrs
  Data analysis, preparation and submission of reports: 105 hrs
- Exam preparation:
  60 hrs

M 4.25 Module: Key Competencies [M-MACH-106945]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering
Part of: Interdisciplinary Electives

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	pass/fail	Each term	1 term	English	4	1

Election Notes
Interdisciplinary qualifications (IQ) completed at the House of Competence (HoC), at the Zentrum für Angewandte Kulturwissenschaft und Studium Generale at the Forum for Science and Society (FORUM, formerly ZAK), or at the Sprachenzentrum (SpZ), can be assigned in self-service.

First, select a partial accomplishment named "self-assignment" in your study schedule, and second, assign an IQ-achievement via the tab "IQ achievements".

ID	Name	Term offered	Credits	Lecturers
Key Competencies (Elective: at least 4 credits)				
T-MACH-111686	Self-Booking-MSc-HOC-SPZ-FORUM-Non-Graded	**WT+ST**	**2 CP**	**Frohnapfel**
T-MACH-113323	Self-Booking-MSc-HOC-SPZ-FORUM-Non-Graded	**WT+ST**	**1 CP**	**Pundt**
T-MACH-111687	Self-Booking-MSc-HOC-SPZ-FORUM-Graded	**WT+ST**	**2 CP**	**Frohnapfel**
T-MACH-113322	Self-Booking-MSc-HOC-SPZ-FORUM-Graded	**WT+ST**	**1 CP**	**Pundt**

Assessment
Depending on individual choice.

Prerequisites
none

Competence Goal
After completing the module Key Competences students can

- determine and coordinate work steps, projects and goals, proceed systematically and purposefully, set priorities as well as assess the feasibility of a task,
- apply the principles of safeguarding good scientific practice,
- apply methods for the planning of a specific task under given framework conditions in a goal- and resource-oriented way,
- describe methods for scientific research and selection of technical information according to pre-established quality criteria and apply them to given problems,
- discuss empirical methods and apply them to selected examples,
- present technical information in a clear, readable, and convincingly argued manner in various forms of presentation (e.g. poster, exposé, abstract) in writing and appropriately visualize it graphically,
- present and stand up for technical content in a convincing and appealing way,
- work as a team in a task-oriented manner, handle any conflicts on their own and take responsibility for themselves and others,
- communicate as a team in an objective, goal-oriented and interpersonal manner, represent their own interests, reflect and take into account the interests of others in their own words, and successfully organize the course of the conversation.

Content
depending on individual choice

Workload
The workload is approx. 120 hours, which corresponds to 4 credits.

Teaching and Learning Methods
lectures, seminars, tutorials, lab courses.

M 4.26 Module: Machine Dynamics II [M-MACH-107100]

Coordinators: Prof. Dr.-Ing. Carsten Proppe
Organisation: KIT Department of Mechanical Engineering
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-105224	Machine Dynamics II	**WT**	**4 CP**	**Proppe**

Assessment
see course

Prerequisites
none

Competence Goal
XXX

Content
Students are able to develop and analyze detailed models in machine dynamics, including continuum models, fluid-structure interaction, stability analysis.

Plain bearings

- Rotating shafts in plain bearings

- Belt drives

- Blade vibrations

Module Grade Calculation
The module grade corresponds to the grade of the exam.

Workload
Total: 120 hours

4.27 Module: Master's Thesis [M-MACH-106969]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering

Part of: Master's Thesis

Credits	Grading	Recurrence	Duration	Language	Level	Version
30 CP	graded	Each term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-113931	Master's Thesis	WT+ST	30 CP	Böhlke

Assessment
The Master's thesis module consists of a written paper (Master's thesis) and an oral presentation. The presentation must take place within six weeks of submission of the Master's thesis.

With their thesis, students should demonstrate that they are able to work on a problem from their field of study independently and within a limited period of time using scientific methods.

The maximum working time is six months. The topic and assignment must be adapted to the planned scope. The examination committee specifies the languages
in which the master's thesis can be written. At the student's request, the examiner may authorize the Master's thesis to be written in a language other than English.

The time of assignment of the subject of the master's thesis is recorded by the
supervisor and the student/s and documented in the files of the examination committee
four weeks after the start of work on the master's thesis at the latest. The topic may only be returned once and only within the first month of the completion period.

Upon justified request by the student, the Examination Board may extend the completion period by a maximum of three months. If the Master's thesis is not submitted on time, it is deemed to have been assessed as "insufficient" (5.0), unless the student is not responsible for this failure.

The Master's thesis is assessed by at least one university professor at KIT or a habilitated member of the KIT Departments of Mechanical Engineering or Chemical and Process Engineering and one other examiner. As a rule, one of the examiners is the person who assigned the thesis.

If these two persons do not agree in their assessment, the Examination Board determines the grade of the Master's thesis based on the assessment of these two persons; it may also appoint a further assessor.

The assessment must take place after the presentation and within eight weeks of submission of the Master's thesis.

Prerequisites
The prerequisite for admission to the master's thesis module is that the student has successfully passed module examinations totaling 74 CP.

As to exceptions, the examination board decides on a request of the student (see § 14 (1) SPO).

Modeled Prerequisites
The following conditions have to be fulfilled:

1. You need to have earned at least 74 credits in your study program.

Competence Goal
The student is able to work independently on a defined, subject-relevant theme based on scientific criteria within a given period of time. The student is able to do research independently, to analyze information, to abstract as well as collect and recognize basic principles and regularities on the basis of less structured information. He/she overviews the given scientific question, is able to choose sophisticated scientific methods and techniques, and use them to solve this question and to identify further potentials, respectively. In addition, this will be carried out in consideration of social and/or ethical aspects.

The student can interpret, evaluate, and if needed plot the results obtained in a more sophisticated way. He/she is able to clearly structure his scientific work and (a) to communicate it in written form using state-of-the-art technical terminology as well as (b) to present it in oral form and discuss it with experts.

Content
The student shall be allowed to make suggestions for the topic of his/her master thesis. The topic is set by the supervisor of the thesis in accordance with § 14 (3) SPO.

Workload
The workload for the preparation and presentation of the master thesis is about 900 hours.

M 4.28 Module: Mathematical Methods in Fluid Mechanics [M-MACH-107687]

Coordinators: Prof. Dr.-Ing. Bettina Frohnapfel
Organisation: KIT Department of Mechanical Engineering

Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German/English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-113956	Mathematical Methods in Fluid Mechanics	**WT**	**6 CP**	**Frohnapfel, Gatti**

Assessment
written exam - 90 minutes

Competence Goal
Students deepen and explain mathematical methods for solving the Navier-Stokes equations. They transfer these to technical problems. They are able to select suitable methods and discuss their application critically.

Content
The students can simplify the Navier-Stokes equations for specific flow problems. They are able to employ mathematical methods in fluid mechanics effectively in order to solve the resulting governing equations analytically, if possible, or to enable simpler numerical solution of the problem. The students can describe the limits of applicability of the assumptions made to model the flow behavior.

The lecture will cover a selection of the following topics:

- Creeping flows (Stokes flow)
- Lubrication theory
- Potential flow theory
- Boundary-layer theory
- Laminar-turbulent transition (linear stability theory)
- Turbulent flows

Module Grade Calculation
result of exam

Workload
The work load is about 190 hours, of which 45 hours are in presence and 145 hours individual learning time. This corresponds to 6 credit points.

Teaching and Learning Methods
Lecture, Tutorial

Literature
Kundu, P.K., Cohen, K.M.: Fluid Mechanics, Elsevier, 4th Edition, 2008

Kuhlmann, H.: Strömungsmechanik, Pearson, 2007

Spurk, J. H.: Strömungslehre, Springer, 2006

Zierep, J., Bühler, K.: Strömungsmechanik, Springer, 1991

Schlichting H., Gersten K., Grenzschichttheorie, Springer, 2006

Kundu, P.K., Cohen, K.M.: Fluid Mechanics, Elsevier, 4th Edition, 2008

Batchelor, G.K.: An Introduction to Fluid Dynamics, Cambridge Mathematical Library, 2000

Pope, S. B.: Turbulent Flows, Cambridge University Press, 2000

Ferziger, H., Peric, M.: Computational Methods for Fluid Dynamics, Springer, 2008

M 4.29 Module: Mechanics [M-MACH-106947]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering
Part of: Core Competencies

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-113939	Computational Mechanics of Materials	**WT**	**4 CP**	**Böhlke**
T-MACH-113940	Tutorial Computational Mechanics of Materials	**WT**	**2 CP**	**Böhlke**

Assessment
T-MACH-113939: Written examination, duration: 90 minutes

T-MACH-113940: Coursework, Details are announced in the first lecture

Prerequisites
none

Competence Goal
After completing the module, students will know the basics of continuum mechanics. This includes tensor calculus, kinematics, balance equations and material theory. Graduates will be able to explain the core elements of material modeling and apply them to problems in the theory of elasticity, viscoelasticity and plasticity. Students will be able to transfer their knowledge of material modeling to advanced problems in continuum thermomechanics. Graduates will be familiar with various mathematical solutions and will be able to select and apply these in a targeted manner.

Content

- Kinematics
- Balance equations
- Basics of material modeling
- Theory of elasticity
- Theory of viscoelasticity
- Theory of plasticity

Additional Information
none

Workload
Lecture:

- Attendance time: 30 h
- Preparation and follow-up: 30 h
- Exam preparation: 60 h

Exercises :

- Attendance times: approx. 22 h
- Preparation and follow-up: approx. 38 h

Recommendations
none

Teaching and Learning Methods
Lecture and exercises

Base For
none

M 4.30 Module: Modeling of Polymer and Suspension Flows for Industrial Manufacturing Processes [M-MACH-107102]

Coordinators: Prof. Dr.-Ing. Luise Kärger
Dr.-Ing. Florian Wittemann
Organisation: KIT Department of Mechanical Engineering
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-114949	Modeling of Polymer and Suspension Flows for Industrial Manufacturing Processes	**ST**	**4 CP**	**Kärger, Wittemann**

Assessment
see course

Prerequisites
none

Competence Goal

- Students can describe and model the viscosity of polymer melts.
- Students can explain and evaluate important numerical methods with regard to their suitability for a problem.
- Students can name the advantages and disadvantages of different processes and select a suitable process for a specific problem.
- Students can describe and explain the different approaches for modeling selected processes and decide for a suitable one.

Content
The lecture deals with the behavior of (fiber-reinforced) polymers in the molten state and in the context of industrially relevant manufacturing processes. The manufacturing process of fiber composite components has a significant influence on the subsequent component behavior. Accordingly, it is just as important to be able to map the material behavior during production as it is to be able to map the subsequent component behavior. For this purpose, the lecture deals with the modeling of viscosity and flow of polymers (with and without fibers). The basics of numerical simulation of flows are taught and advanced models for describing certain manufacturing processes are explained. Accordingly, important advantages and disadvantages of different manufacturing processes and their respective modeling approaches are taught. At the end of the lecture, students will be able to select suitable modeling approaches for specific processes and mathematically describe the behavior of polymers in the molten state.

Module Grade Calculation
The module grade corresponds to the grade of the exam.

Workload
Total: 120 hours, of which 30 hours attendance, 90 hours self-study

4.31 Module: Modeling of Turbulent Flows - RANS and LES [M-BGU-105362]

Coordinators: Prof. Dr.-Ing. Markus Uhlmann
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-110842	Modeling of Turbulent Flows - RANS and LES	**WT+ST**	**6 CP**	**Uhlmann**

Assessment
- module component T-BGU-110842 with oral examination according to § 4 Par. 2 No. 2

details about the learning control, see module component

Prerequisites
none

Competence Goal
Participants are able to weigh the prosand cons of the different modeling approaches; they are further able to choose an appropriate approach for a given application. Participants have the ability to critically evaluate the expected outcome of a range of turbulence models with respect to their predictive capabilities and the required computational effort.

Content
In this module covers the required mathematical tools and the most useful modeling approaches for fluids engineering problems. First the statistical approach to turbulence modeling, based upon Reynolds averaging (RANS) is presented, starting with the simplest algebraic model and ranging up to Reynolds stress transport models. Furthermore, an introduction to the concept of large-eddy simulation (LES) is given.

Module Grade Calculation
grade of the module is grade of the exam

Additional Information
none

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- Modeling of Turbulent Flows - RANS and LES lecture, exercise: 60 h

independent study:

- preparation and follow-up lectures, exercises Modeling of Turbulent Flows - RANS and LES: 60 h
- examination preparation: 60 h

total: 180 h

Recommendations
basic fluid mechanics (experience in working with the Navier-Stokes equations)
mathematics (analysis – partial differential equations, Fourier series, vectors/tensors, matrices and eigenvalues; statistics)
knowledge in programming with Matlab is recommended; otherwise it is strongly recommended to participate in the course 'Introduction to Matlab';

taking the module 'Fluid Mechanics of Turbulent Flows' preliminarily is strongling recommended.

M 4.32 Module: Multiscale and Multiphysics Modeling for Porous Building Materials [M-BGU-107828]

Coordinators: Dr. Ravi Ajitbhai Patel
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-115230	Multiscale and Multiphysics Modeling for Porous Building Materials	**ST**	**6 CP**	**Patel**

Assessment
- module component T-BGU-115229 with examination of another type according to § 4 Par. 2 No. 3

details about the learning control, see module component

Prerequisites
none

Competence Goal
By the end of the course, students will be able to develop a deeper understanding of coupled thermo–hydro–chemo–mechanical (THCM) processes in context of porous building materials. Students will be able to set up and run THCM simulations using both commercial software and an open-source Python toolbox. Students will be able to parameterize the governing THCM equations through multiscale modelling, applying hierarchical upscaling techniques with numerical and/or analytical homogenization. Students can implement the two homogenization techniques and extract effective material parameters for subsequent simulation at continuum scale.

Content
The course develops a detailed understanding of the fundamental principles that govern the modelling of porous materials, using building materials as the main reference case. It begins with the theoretical foundations of thermo-hydro-chemo-mechanical (THCM) simulations and shows how these governing equations are parameterized through multiscale methods. Lectures combine slide presentations with worked examples and encourage interactive participation.

<u>Multiphysics Modeling:</u>

We first distinguish continuum-scale descriptions from pore-scale phenomena and discuss the key characterization parameters of porous media. After introducing the conservation laws and the volume-averaging framework used to derive continuum equations, the module treats each individual process in turn: single- and two-phase flow, heat transport in multiphase media, chemical transport considering phase reactions, and non-linear solid mechanics (plasticity and damage). Finally coupling strategies are discussed for THCM processes with main focus on heuristic approach based on coupling through constitutive laws. Throughout the course, hands-on demonstrations and practical implementations are provided to deepen theoretical understanding. This is carried out in virtual lab setting provide hands on case studies based on porous building materials.

<u>Multiscale Modeling:</u>

This part of the course shows how to obtain the effective material parameters required in the THCM equations. Emphasis is placed on hierarchical upscaling, with two homogenization strategies viz., analytical and numerical explored in depth. Implementation aspects are covered for thermal, transport, and linear-elastic mechanical properties, giving students the tools to bridge scales from the microstructure to the continuum description.

Module Grade Calculation
grade of the module is grade of the exam

Additional Information
The module will be offered newly as from winter term 2026/27.

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- lecture/exercise: 60 h

independent study:

- preparation and follow-up lecture/exercises: 40 h
- implementation of case study: 60 h
- preparation of presentation (examination): 20 h

total: 180 h

Recommendations
Prior familiarity with differential equations and basics of continuum mechanicsis assumed.

4.33 Module: Multivariable Control Systems [M-ETIT-107515]

Coordinators: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-ETIT-114727	Multivariable Control Systems		6 CP	Hohmann

Assessment
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal

- The students are able to describe linear multivariable Systems in time and frequency domain with as well time continous as time discrete models.
- In particular the students are familiar with the state space representation and its transformations in canonical forms.
- The students are able to analyze multivariable system with respect to stability, trajectory plots in state space, controllability, observability and zeros and poles.
- They master the control of linear multivariable systems in frequency domain by series decoupling with frequency control.
- The students are familiar with the basic control structures in time domain (pole placement with preliminary filter).
- The students are able to use different methods for direct pole placement in state space via state feedback like the Ackermann formula, modal synthesis and the complete modal synthesis.
- They are able to synthesize controllers for the decoupling control of multivariable systems in state space.
- The students are able to design time discrete controllers, in particular dead-beat control.
- They are familiar with the problem of determining non measurable state variables using complete and reduced state observers.
- As an extension, they are able to solve a generalized estimation problem in state space including noise by the design of Kalman filters.
- They can apply state feedback methods for the elimination of permanent deterministic disturbances like disturbance feedforward control, use of disturbance models or PI-State space controllers.
- The students can apply complete modal synthesis to design output feedback controllers in state space.
- They are able to extend the state feedback control with dynamical elements in order to create dynamical controllers.

Content
The module is designed to provide students with basic knowledge and skills to analyze linear multivariable dynamic systems (described both in continuous and discrete time) and to design respective controllers. Furthermore the students are enabled to handle poor sensor information by state estimation methods or to eliminate disturbances and uncertainties, for example by dynamic state feedback.

Module Grade Calculation
The module grade is the grade of the written exam.

Workload
The workload includes (4 SWS):

1. attendance in lectures and exercises: 15*4 h = 60 h
2. preparation / follow-up: 15*4 h = 60 h
3. preparation of and attendance in examination: 60 h

A total of 180 h = 6 CR

Recommendations
Basic knowledge in the field of control theory is required (for example the contents of the bachelor module M-ETIT-106339 “Mess- und Regelungstechnik”).

Teaching and Learning Methods
lecture (3 SWS), exercise (1 SWS)

4.34 Module: Nonlinear Continuum Mechanics [M-MACH-107110]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Chemical and Process Engineering
KIT Department of Mechanical Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-111026	Nonlinear Continuum Mechanics	**ST**	**6 CP**	**Böhlke**
T-MACH-111027	Tutorial Nonlinear Continuum Mechanics	**ST**	**2 CP**	**Böhlke**

Assessment
see course

Prerequisites
none

Competence Goal
Upon successful completion of this module, the students can

- derive the kinematics of finite deformations
- derive balance equations in regular and irregular points
- discuss the principle of material theory
- discuss the basics of special material classes
- apply elements of crystal plasticity to examples

Content

- Tensor calculus and kinematics
- Eulerian and Lagrangian description
- Balance equations and transport theorem
- Principles of material theory
- Discussion of special material classes and their description

Module Grade Calculation
The module grade corresponds to the weighted average of the courses according to the explicit data.

Workload
Total: 240 hours, of which 90 hours attendance, 150 hours self-study

Recommendations
Good knowledge of linear continuum mechanics is necessary

M 4.35 Module: Nonlinear Control Systems [M-ETIT-107644]

Coordinators: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-ETIT-114989	Nonlinear Control Systems	**ST**	**6 CP**	**Kluwe**

Assessment
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal

- The students are able to describe nonlinear systems in time domain, in particular they are familiar with the state space representation.
- The students are able to analyze the behavior of nonlinear systems on the basis of the respective trajectory plots in state space.
- They master the stability analysis of equilibrium points with the fundamental Lyapunov theory and its extensions.
- They are familiar with the passivity concept in nonlinear systems.
- They are as well familiar with dissipativity as the generalization of passivity.
- They are able to design controllers with control Lyapunov functions.
- They master the controller design with the back-stepping principle.
- They are able to design sliding-mode control in nonlinear systems.
- They are able to synthesize passivity-based controllers.
- They are able to use design compensation control methods with feedback linearization on the basis of relative degree.
- They can design controllers based on the concept of flatness.

Module Grade Calculation
The module grade is the grade of the written examination.

Workload
The workload includes (4 SWS):

1. attendance in lectures and exercises: 15*4 h = 60 h
2. preparation / follow-up: 15*4 h = 60 h
3. preparation of and attendance in examination: 60 h

A total of 180 h

Recommendations
Basic and advanced knowledge knowledge in the field of control theory is recommended (for example the contents of the bachelor module M-ETIT-106339 “Mess- und Regelungstechnik” and the master module M-ETIT-107515 “Multivariable Control Systems”)

Teaching and Learning Methods
Lecture (3 SWS) + exercises (1 SWS)

4.36 Module: Nonlinear Process Control [M-CIWVT-106316]

Coordinators: Prof. Dr.-Ing. Thomas Meurer
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-112824	Nonlinear Process Control		**6 CP**	**Meurer**

Assessment
Learning control is an oral examination with a duration of about 45 minutes.

Prerequisites
None

Competence Goal
Students will gain an in-depth understanding of methods and concepts for analyzing and controlling nonlinear dynamic systems. They will understand the underlying mathematical concepts and be able to apply them to new problems. They will gain a comprehensive understanding of nonlinear control concepts and be able to apply these methods independently to specific problems, both analytically and with the aid of computer algebra systems.

Content
Nonlinearities are ubiquitous in nature. Differing from linear control theory and linear control systems, which typically rely on the local linearization of a nonlinear system around some equilibrium, this module addresses nonlinear concepts for the analysis and the control of nonlinear systems. The course covers the following topics:

- Introduction to the dynamic analysis of nonlinear systems
- Differential geometric concepts
- Exact feedback linearization
- Differential flatness and flatness-based feedforward and tracking control
- Lyapunov theory and Lyapunov-based design methods

Problem sets are considered in the exercises to apply the developed methods using analytical tools as well as computer algebra systems to realize the design approaches.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Attendance time: Lectures: 30 hrs. Exercises: 15 hrs.

Self-study: 75 hrs.

Exam preparation: 60 hrs.

Literature

- T. Meurer: Nonlinear Process Control, Lecture Notes.
- B. Brogliato, R. Lozano, B. Maschke, O. Egeland: Dissipative systems analysis and control, Springer, 2007.
- H. Nijmeijer, A.J. van der Schaft: Nonlinear Dynamical Control Systems. Springer, 1991.
- Isidori: Nonlinear Control Systems. Springer-Verlag, 1995.
- H. K. Khalil: Nonlinear Systems, Prentice Hall, 2002.
- M. Krstic, I. Kanellakopoulos, P. Kokotovic: Nonlinear and Adaptive Control Design, John Wiley & Sons, 1995.
- S. Sastry: Nonlinear Systems, Analysis, Stability, Control. Springer-Verlag, 1999.
- A. J. van der Schaft: L2-gain and passivity techniques in nonlinear control, Springer, 2016.
- M. Vidyasagar: Nonlinear Systems Analysis, SIAM, 2002.

M 4.37 Module: Numerical Fluid Mechanics [M-BGU-103375]

Coordinators: Prof. Dr.-Ing. Markus Uhlmann
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-106758	Numerical Fluid Mechanics	**WT+ST**	**6 CP**	**Uhlmann**

Assessment
- module component T-BGU-106758 with written examination according to § 4 Par. 2 No. 1

details about the learning control, see module component

Prerequisites
none

Competence Goal
Students are enabled to describe the fundamental approaches of numerical solution of flow problems. They are capable of evaluating the advantages and disadvantages of these approaches in the various areas of application, enabling them to make an appropriate choice. Participants are able to apply the numerical methods to simple flow problems; this involves the generation and application of basic computer programs. They are able to analyze the results with respect to precision, stability and efficiency.

Content
This module constitutes a general introduction to the numerical solution of flow-related problems. The mathematical properties of the conservation equations are analyzed. The principles of numerical discretization are studied with the aid of the finite-difference and the finite-volume method. The concept of numerical stability is introduced, and various techniques of error analysis are presented theoretically and by way of examples

Module Grade Calculation
grade of the module is grade of the exam

Additional Information
none

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- lecture, exercise: 60 h

independent study:

- preparation and follow-up lectures, exercises: 60 h
- examination preparation: 60 h

total: 180 h

Recommendations
basic knowledge in hydromechanics (understanding of physical processes of advektion and diffusion, handling of Navier-Stokes equations) and advanced mathematics (analysis - partial differential equations, Fourier analysis, series expansion, complex numbers; linear algebra - matrices, determinants, eigenvalue analysis), numerics (discrete number representation, round-off, floating point operations, numerical treatment of partial differential equations)

M 4.38 Module: Numerical Methods for Engineering Applications [M-MACH-107851]

Organisation: KIT Department of Electrical Engineering and Information Technology
KIT Department of Mechanical Engineering

Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-115242	Numerical Methods for Engineering Applications	**ST**	**4 CP**	**Kärger**

Assessment
written exam

Competence Goal
The students will be able to

- name and explain the balance equations and give examples of constitutive laws,
- construct models for continuum mechanical problems,
- explain model reduction approaches,
- explain the basic assumptions and techniques of the numerical methods covered (MWR, FDM, FEM, FVM), implement them in software and evaluate their suitability for given problems.

Content
Simulations are used in many areas of mechanical engineering, such as the strength and crash calculation of components or the calculation and design of flow processes. They offer the possibility of predicting real physical effects with the aid of computers, thus providing a deeper understanding of the observed effects and their causes. The aim of the course is to provide students with the fundamentals for the successful generation and execution of simulations in mechanical engineering.

Conservation equations are formulated for modelling. To close the system of equations, constitutive equations must also be formulated. The resulting partial differential equations (PDEs) are usually space and time dependent and form the fundamental components of modelling. The PDEs in question usually cannot be solved analytically, so that numerical methods and, in most cases, discretization methods are required.

The creation of suitable simulation models, the execution and evaluation of simulation studies and the avoidance of typical errors can be learnt, but also require some practice. Therefore, the course consists of three elements: Lectures, classroom exercises and computer exercises. As part of the computer exercises, students learn to implement (in Python), apply and evaluate appropriate simulation methods for given problems.

Course structure (with lectures (L), exercises (Ex) and/or computer exercises (PC))

- Introduction: model definition, overview of numerical simulation methods (L)
- Tensor calculus, Python and Git (L, Ex, PC)
- Equilibrium equations, constitutive laws, model reduction (L, Ex)
- Method of Weighted Residuals (MWR) (L, Ex)
- Finite Difference Method (FDM) (L, Ex, PC)
- Finite Element Method (FEM) (L, Ex, PC)
- Finite Volume Method (FVM) (L, Ex, PC)
- Selection of methods (L)

Workload
120h

Literature

- Bathe, K.-J.: Finite Element Procedures, Prentice Hall, Pearson Education (1st ed.) / Watertown, MA (2nd ed.), 2014. ISBN: 978-0-9790049-5-7
- Belytschko, T., Liu, W. K., Moran, B., & Elkhodary, K.. Nonlinear finite elements for continua and structures. John Wiley & Sons, 2014.
- Ferziger, J. H., Peric, M.: Numerische Strömungsmechanik, Springer-Verlag, 2008. https://doi.org/10.1007/978-3-662-46544-8
- Ferziger, J. H., Peric, M.: Computational Methods for Fluid Dynamics. Springer-Verlag, 2020. https://doi.org/10.1007/978-3-319-99693-6
- Gurtin, M.E.; Fried E.; Anand, L.: The mechanics and thermodynamics of continua, Cambridge University Press, 2010. ISBN: 978-0-521-40598-0
- Hirsch, C.: Numerical Computation of Internal and External Flows, Vol. I, II, Wiley, 2007. ISBN: 978-0-7506-6594-0
- Schäfer, M.: Computational Engineering – Introduction to Numerical Methods, Springer-Verlag, 2006. https://doi.org/10.1007/978-3-030-76027-4

4.39 Module: Numerical Simulation of Reacting Multiphase Flows [M-CIWVT-107076]

Coordinators: Prof. Dr. Oliver Thomas Stein
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each summer term	1 term	English	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-114117	Numerical Simulation of Reacting Multiphase Flows - Prerequisite		**5 CP**	**Stein**
T-CIWVT-114118	Numerical Simulation of Reacting Multiphase Flows		**3 CP**	**Stein**

Assessment
The learning control consists of two partial achievements:

1. Completed Coursework: As a prerequisite for the oral exam, reports on the tutorial have to be submitted. These document the processed task, the generated data and their analysis.
2. Oral examination lasting approx. 30 minutes.

Prerequisites
The completed coursework is a prerequisite for participation in the oral examination.

Competence Goal
Course participants can explain basic and advanced concepts related to the modelling and simulation of reacting multiphase flows. They are knowledgeable of the governing equations of both single and multiphase flows and can describe the physical meaning of all terms in these equations. They can explain the fundamentals of turbulence and turbulence modelling, chemical conversion and multiphase flow modelling. They are knowledgeable of numerical approximation and solution methods for reacting multiphase flows and know how to apply them. In the related tutorials with the OpenFOAM software, they have obtained a first practical experience in setting up, running and analysing their simulations and are capable of applying the obtained knowledge to further simulation tasks.

Content

- Basics of computational fluid dynamics
- Governing equations, turbulence & turbulence modelling
- Chemical conversion and reacting flows
- Non-reacting and reacting multiphase flows
- Numerical approximation and solution methods

Module Grade Calculation
The module grade ist the grade of the oral exam.

Additional Information
The OpenFOAM tutorials will be conducted on the students' laptops.

Workload

- Attendance time
  Lectures 2 SWS: 30 h
  Tutorials 2 SWS: 30 h
- Self-study
  Preparation and wrap-up lectures: 15 h
  Data analysis, preparation and submission of reports: 105 h
- Exam preparation:
  60 h

Literature
Will be announced.

4.40 Module: Optimal and Model Predictive Control [M-CIWVT-106317]

Coordinators: Prof. Dr.-Ing. Thomas Meurer
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-112825	Optimal and Model Predictive Control		**6 CP**	**Meurer**

Assessment
Learning control is an oral examination with a duration of about 45 minutes.

Prerequisites
none

Competence Goal
Students will gain an in-depth understanding of dynamic optimization with constraints, optimal control, and model predictive control. They will understand the underlying mathematical concepts and be able to apply them to new problems. They will gain a comprehensive understanding of optimization methods and be able to apply these methods independently to dynamic optimization problems. Students are familiar with various numerical solution approaches, understand how they work, and can implement them for optimization problems.

Content
Many problems in industry and economy rely on the determination of an optimal solution satisfying desired performance criteria and constraints. In mathematical terms this leads to the formulation of an optimization problem. Here it is in general distinguished between static and dynamic optimization with the latter involving a dynamical process. This lecture gives an introduction to the mathematical analysis and numerical solution of dynamic optimization problems with a particular focus on optimal control and model predictive control. The lecture addresses the following topics:

- Fundamentals of dynamic optimization problems
- Dynamic optimization without and with constraints
- Linear and nonlinear model predictive control
- Numerical methods

Selected examples are considered and solved in the exercises and dedicated computer exercises.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Attendance time: Lectures: 30 hrs. Exercises: 15 hrs.

Self-study: 60 hrs.

Exam preparation: 75 hrs.

Literature

- T. Meurer: Optimal and Model Predictive Control, Lecture Notes.
- D. G. Luenberger, Y. Ye: Linear and Nonlinear Programming, Springer, 2008.
- J. Nocedal, S.J. Wright: Numerical Optimization, Springer, 2006.
- M. Papageorgiou, M. Leibold, M. Buss: Optimierung, Springer, 2012.
- E. Camacho, C. Alba: Model Predictive Control, Springer, 2004
- L. Grüne, J. Pannek: Nonlinear Model Predictive Control: Theory and Algorithms, Springer, 2011.
- L. Wang: Model Predictive Control System Design and Implementation Using MATLAB, Springer, 2009.

4.41 Module: Optimal Control [M-ETIT-107497]

Coordinators: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-ETIT-114701	Optimal Control	WT	6 CP	Hohmann

Assessment
The assessment consists of a written exam (120 min) taking place in the recess period.

Prerequisites
none

Competence Goal

- The students know as well the mathematical basics as the fundamental methods and algorithms to solve constraint and unconstraint nonlinear static optimization problems.
- They can solve constraint and unconstraint dynamic optimization by using the calculus of variations approach and the Dynamic Programming method.
- The students understand and can apply the Bellman Principle, including its theoretical foundations and practical relevance.
- Also they are able to transfer dynamic optimization problem to static problems.
- They are proficient in formulating Optimal Control Problems and applying Model Predictive Control techniques
- The students know the mathematic relations, the pros and cons and the limits of the particular optimization methods.
- They can transfer problems from other fields of their studies in a convenient optimization problem formulation and they are able to select and implement suitable optimization algorithms for them by using common software tools.

Content
The module teaches the mathematical basics that are required to solve optimization problems. The first part of the lecture treats methods for solving dynamic optimization problems, including Dynamic Programming and methods derived from the calculus of variations, such as the Hamilton method.

This is followed by a section on optimal control problems. After presenting techniques to transform dynamic optimization problems into static ones, the final part of the lecture addresses methods for solving static optimization problems, both constrained and unconstrained.

Module Grade Calculation
The module grade is the grade of the written exam.

Additional Information
Successor of "M-ETIT-100531 - Optimization of Dynamic Systems"

Workload
The amount of work includes

1. presence in lecture/exercises/tutorial(optional) (2+2 SWS: 60h)
2. preparation/postprocessing of lecture/exercises (90h)
3. preparation/presence in the written exam (30h)

Teaching and Learning Methods
lecture (2 SWS), excercise (2 SWS)

4.42 Module: Parallel Computing [M-MATH-101338]

Coordinators: PD Dr. Mathias Krause
Prof. Dr. Christian Wieners

Organisation: KIT Department of Mathematics

Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	German/English	4	3

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MATH-102271	Parallel Computing	**Irreg.**	**6 CP**	**Krause, Wieners**

Assessment
Examination prerequisite: passed computer lab

Success is assessed in the form of an oral examination lasting approx. 20 minutes.

Prerequisites
None

Competence Goal
Graduates

- know the fundamentals of parallel computing,
- have an overview of scientific computing concepts on parallel computers,
- have theoretical and practical experience with parallel programming models and parallel solution methods,
- can independently implement simple practical tasks in a scalable manner

Content

- Parallel programming models
- Parallel solving of linear equation systems
- Parallel finite differences, finite elements, finite volumes methods
- Domain decomposition methods
- Parallel matrix-matrix and matrix-vector operations
- Convergence and performance analysis
- Load balance techniques
- Applications from the natural sciences and engineering

Module Grade Calculation
The module grade is the grade for the oral examination.

Workload
Total workload: 180 hours

Attendance time: 60 hours

- Course including module examination

Self-study: 120 hours

- Consolidation of course content through follow-up work on lecture content at home
- Completion of exercises
- Consolidation of course content using appropriate literature and internet research
- Preparation for the module examination

Recommendations
Knowledge of a higher-level programming language (C++, Java, Fortran) and basic knowledge of the numerical treatment of differential equations (finite differences or finite elements) are recommended.

Teaching and Learning Methods
Lecture + computer-based tutorial in the lab (2+2 weekly contact hours)

M 4.43 Module: Particle Dynamics and Atomistic Simulation [M-MACH-107731]

Coordinators: Dr.-Ing. Johannes Schneider
Dr. Daniel Weygand

Organisation: KIT Department of Mechanical Engineering

Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-114129	Particle Dynamics and Atomistic Simulation	**ST**	**4 CP**	**Gumbsch, Schneider, Weygand**

Assessment
oral exam: approximately 30 minutes

Prerequisites
none

Competence Goal
The student will be able to

- explain the physical principles of particle-based simulations,
- describe the application areas of particle-based simulation methods,
- apply particle-based simulation methods to address problems in materials science, materials engineering, and process engineering.

Content
Particle-based methods are numerical techniques used to simulate and analyse systems consisting of many discrete particles. They are particularly useful in fields where traditional continuum mechanical approaches are insufficient, such as granular materials, complex fluids, and defects in solids. In the lecture, the Discrete Element Method (DEM) for particles and Molecular Dynamics (MD) for the atomistic description of material behaviour will be covered. These methods span different length and time scales.

1. Introduction to Particle-Based Methods
   a) origin and application
   b) classification of particle-based methods
2. Fundamentals of Particle Dynamics
   a) Newtonian mechanics and conservation laws
   b) contact mechanics and friction laws
   c) kinematics and dynamics of particles
3. Discrete Element Method (DEM)
   a) principles and fundamentals
   b) numerical implementation: discretizing space and time
   c) particle detection and contact modelling
   d) application examples
4. Atomistic Methods: Molecular Dynamics (MD) and Statics (MS)
   a) fundamentals of atomistic models
   b) interaction: interatomic potentials
      i. pair potentials and their limits
      ii. many-body potentials
   c) integration methods (e.g., Verlet, Leap-Frog)
   d) periodic boundary conditions and neighbour lists
   e) applications in materials science
5. Structural Analysis:
   a) classification of neighbourhoods, distribution functions
   b) defect energy
   c) stresses, strains
6. Statistical Aspects of Atomistic Models
   a) phase space
   b) physical ensembles: microcanonical, canonical, grand canonical
   c) control of temperature, pressure, stresses: thermostats and barostats
   d) fluctuations and physical properties

The lecture covers both fundamental and advanced aspects of particle-based methods, with a particular focus on simple atomistic approaches. The accompanying computer exercises are designed to deepen and complement the lecture content through practical examples using the freely available particle simulation tool "LAMMPS" and to serve as a forum for detailed questions from students.

Module Grade Calculation
grade of the oral exam

Workload
Lecture: 22.5 hours

Exercises: 12 hours

Self-study: 85.5 hours

Recommendations
Recommended Prerequisites: mathematics, physics, and materials science

Teaching and Learning Methods
lectures and exercices

Literature

- Understanding Molecular Simulation: From Algorithms to Applications, Daan Frenkel and Berend Smit (Academic Press, 2001)
- Computer simulation of liquids, M. P. Allen and Dominic J. Tildesley (Clarendon Press, Oxford, 1996)
- Computational Granular Dynamics. T. Pöschel, T. Schwager, Springer, 2005. Diskrete Element Methoden.
- Lecture Slides and Exercises.

M 4.44 Module: Phase-Field Method in Thermomechanics [M-MACH-107459]

Coordinators: Dr.-Ing. Andreas Prahs
Organisation: KIT Department of Mechanical Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	2

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-114540	Phase-Field Method in Thermomechanics	**ST**	**4 CP**	**Prahs**

Assessment
see individual course

Prerequisites
none

Competence Goal
The students:

- understand the physical and mathematical principles of the phase field method for describing microstructure evolution,
- know the different approaches to derivation (e.g. variational, energetic and mechanical) and can evaluate their respective advantages and disadvantages,
- can analyse thermomechanically consistent PFM models and classify them with regard to latent heat and material laws,
- can also compare classical and current modelling approaches and reflect on their application limits.

Content
The phase field method (PFM) is an established tool for simulating microstructure evolution. It enables the numerically efficient tracking of interfaces between different phases. The spatial affiliation of different phases is characterized by so-called order parameters. These order parameters can be interpreted as continuous indicator functions whose evolution is given by a partial differential equation. The area of application includes phase transitions such as liquid-liquid, liquid-solid and solid-solid. For the latter, e.g. solidification, growth of precipitates, recrystallization and crack propagation are taken into account.

There are various ways to derive the development equation of the order parameter. While historical works use a variational approach, more modern approaches are based on the application of an extended principle of virtual power or on considerations of the total energy balance invariance. This course provides an overview of the various methods for deriving the phase field method (PFM) in the context of thermomechanics. The lecture aims to discuss the limitations of the PFM derived in each case, particularly with regard to coupling with thermomechanics and taking various material laws into account. To this end, various common and selected new approaches to deriving the PFM will be presented and compared. The consistent coupling of the considered field and evolution equations is discussed in relation to thermomechanics and the role of latent heat due to phase evolution.

Module Grade Calculation
The module grade corresponds to the grade of the examination.

Workload
120 hours, comprising 31.5 hours of lectures and 88.5 hours of self-study.

Teaching and Learning Methods
Lecture in person

M 4.45 Module: Polymer Thermodynamics [M-CIWVT-107781]

Coordinators: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-113796	Polymer Thermodynamics	**WT**	**6 CP**	**Enders, Zeiner**

Assessment
Learning contrl is an oral exam, duration approx. 30 minutes.

Prerequisites
None

Competence Goal
Students are able to understand complex phase equilibria and they are able to calculate these complex phase equilibria and know the required thermodynamic models and the corresponding parameter fitting procedure.

Content

- Phase equilibria of multi-component mixtures (e.g. polymers)
- numerical methods for calculation of complex phase equilibria
- thermodynamic models
- estimation of model parameters

Module Grade Calculation
The grade of the module ist the grade of the oral exam.

Additional Information
In consultation with the students, the lecture may also be conducted in German.

Workload

- Lectures and Exercises: 90 hrs.
- Self-study: 45 hrs.
- Exam preparation: 45 hrs.

Literature
Chemical Thermodynamics for Process Simulation, J. Gmehling, B. Kolbe, M. Kleiber, J. Raray (Eds.), Wiley-VCH, 2012. ISBN: 978-3-527-31277-1.

4.46 Module: Principles of Constrained Static Optimization [M-CIWVT-106313]

Coordinators: Dr.-Ing. Pascal Jerono
Prof. Dr.-Ing. Thomas Meurer

Organisation: KIT Department of Chemical and Process Engineering

Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each winter term	1 term	English	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-112811	Principles of Constrained Static Optimization		**4 CP**	**Jerono, Meurer**

Assessment
Learning control is an oral exam with a duration of about 45 minutes.

Prerequisites
None

Competence Goal
Students have an in-depth understanding of static optimization with constraints. They understand the underlying mathematical concepts and can apply them to new problems. They have a comprehensive understanding of optimization methods and are able to apply these methods independently to static optimization problems. Students are familiar with various numerical solution approaches, understand how they work, and can implement them for optimization problems.

Content
Optimization problems arise in a broad variety in different scientific and engineering domains ranging from the fit of parameter based on a performance criterion to finding extreme values of an objective function and further extending to machine learning applications. While dynamic optimization (addressed on the module M-CIWVT-106317) involves dynamical systems in static optimization the minimization (maximization) of functions subject to equality and inequality constraints is considered. This module gives an introduction to the mathematical analysis and numerical solution of unconstrained and constrained static optimization problems. The lecture addresses the following topics:

- Fundamentals of static optimization problems
- Unconstrained static optimization
- Constrained static optimization
- Numerical methods

Selected examples are considered and solved in the exercises and dedicated computer exercises.

Module Grade Calculation
The grade of the module ist the grade of the oral exam.

Workload
Attendance time: Lectures: 15 hrs. exercises: 15 hrs.

Self-study: 50 hrs.

Exam praparation: 40 hrs.

Literature

- T. Meurer: Optimal and Model Predictive Control, Lecture Notes.
- D. G. Luenberger, Y. Ye: Linear and Nonlinear Programming, Springer, 2008.
- N. Nocedal, S.J. Wright: Numerical Optimization, Springer, 2006.
- M. Papageorgiou, M. Leibold, M. Buss: Optimierung, Springer, 2012.
- S. Boyd, L. Vandenberghe: Convex Optimization, Cambridge University Press, 2004.
- C.T. Kelley. Iterative Methods for Optimization. SIAM, 1999.

M 4.47 Module: Probabilistic Measurement and Estimation [M-MACH-107613]

Coordinators: Prof. Dr.-Ing. Christoph Stiller
Organisation: KIT Department of Mechanical Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-114943	Probabilistic Measurement and Estimation	ST	6 CP	Stiller

Assessment
Written examination
Duration: 60 minutes
Permitted aids: Own collection of formulas (1 DIN A4 sheet)

Prerequisites
none

Competence Goal
The students know basic concepts of statistical and stochastic measurement technology and can apply them to examples.
The students can set up physical models to determine measured variables using estimators and filters.

Content
The growing performance of measurement technology is constantly opening up innovative fields of application for engineers. Digital measurement methods are becoming increasingly important as they offer high performance, especially for complex tasks. Stochastic models of the measurement setup and the generation of measured variables are the basis for meaningful information processing and are increasingly becoming an indispensable tool for engineers, not only in measurement technology.
The lecture is aimed at students of mechanical engineering and related courses,
who wish to acquire an interdisciplinary qualification. It provides an insight into
digital technology and the basics of stochastics. Building on this, estimation methods can be developed that naturally translate into the elegant theory of state observers. Applications in the measurement signal processing of modern environmental sensors (video, lidar, radar) give the lecture a practical orientation and serve to consolidate what has been learned.

Contents of the module include:

1. Amplifiers
2. Digital technology
3. Stochastic modeling for measurement applications
4. Estimation
5. Kaiman Filter
6. Environmental perception

Module Grade Calculation
The module grade is the grade of the written examination.

Workload
In total 120h:

Attendance time: 20 h
Self-study: 100 h

Teaching and Learning Methods
Lecture

Literature
Lecture notes and slides will be provided as free pdf-files. Further recommendations will be announced in the lecture.

M 4.48 Module: Project [M-MACH-106948]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering
Part of: Project

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-115051	Project		**6 CP**	**Böhlke**

Assessment
Presentation of the project results, written elaboration of the project results. Students are provided with a document with instructions on how to prepare the written document.

Prerequisites
none

Competence Goal
Students are able to work in teams to analyze engineering or technical engineering or technical problems. They are able to find one or more solutions for the problem, to compare, discuss and evaluate different solutions if necessary, and finally to pursue a solution and work it out. In doing so, they apply engineering methods for problem solving as well as methods for developing technical solutions. They incorporate the previously defined requirements and development goals and define indicators to verify the achievement of the goals.

Students are able to define and plan individual work steps from the task definition. They are able to communicate their own results in a team, discuss them professionally and sufficiently document the results of the discussion. In addition, they can record and analyze the work results of team members and derive a common solution.

Students are able to independently research relevant, current scientific and technical literature in a structured manner and to include this in their solution. The students are able to document their technical results, whereby they orientate themselves on the statutes for the safeguarding of good scientific practice at KIT and pay particular attention to scientific language expression and citation rules. The students are able to present their project results and put them up for discussion.

Content

- Students solve an engineering or technical problem
- Research of technical and scientific literature
- Presentation of the results (as team)
- Documentation of the results (as team)

Module Grade Calculation
The module grade corresponds to the grade of the exam.

Workload
180 hours, including at least three meetings with supervisor. Additional attendance hours as required and assessed by the project team.

Teaching and Learning Methods
Project work in a team of usually 2-5 students, at least three meetings with the supervisor.

M 4.49 Module: Reactor Modeling with CFD [M-CIWVT-106537]

Coordinators: Prof. Dr.-Ing. Gregor Wehinger
Organisation: KIT Department of Chemical and Process Engineering
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	2

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-113224	Reactor Modeling with CFD		6 CP	Wehinger

Assessment
Learning control is an examination of another type: presentation and term paper.

Prerequisites
None

Competence Goal
The students are able to

- describe and apply the mathematical and physical principles of computational fluid dynamics (CFD),
- use the commercial CFD software STAR-CCM+ independently and thoroughly (preprocessing, solving, postprocessing),
- develop a CFD reactor model for an unknown chemical process engineering problem and investigate alternative reactor designs based on this model,
- analyze and evaluate the results obtained, also using virtual reality (VR),
- identify and evaluate errors and uncertainties in CFD models,
- visualize, present, and critically discuss their CFD results in the form of a final report.

Content

1. Conservation laws for momentum, mass and energy
2. The Finite-Volume-Method, solution algorithms, and boundary conditions
3. Computational meshes
4. CFD- Modelling of chemical reactors
5. Use of virtual reality in CFD
6. Basics of writing a scientific paper

Module Grade Calculation
The module grade is the grade of the examination of another type.

Workload

- Attendance time: 45 h
- Self-study: 90 h
- Exam preparation: 45 h

Literature

- Ferziger, Perić: Numerische Strömungsmechanik; 2020 ; Springer
- Versteeg, Malalasekera; An Introduction to Computational Fluid Dynamics: The Finite Volume Method (2nd Edition); 2007; Pearson

M 4.50 Module: Robotics, Automation, and Systems Control Lab [M-ETIT-107524]

Coordinators: Prof. Dr.-Ing. Mike Barth
Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	2

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-ETIT-114740	Robotics, Automation, and Systems Control Lab	ST	6 CP	Barth, Hohmann

Assessment
The examination takes place in the form of other types of examination. It consists of pitches after every thematic block, a final presentation and an oral examination in the amount of 20 minutes. The overall impression is evaluated.

Prerequisites
none

Competence Goal

- Students are enabled to develop approaches to various problems in a group, solve them, and present and defend their results. In addition, they are able to present their approach, thought processes, applied methods, and results in a comprehensible and scientifically precise style
- Students are able to familiarize themselves independently with a complex technical system and its components
- Students can discuss problem-solving strategies with team members in technical language and argue their preferred solution. Further they are able to reflect on the solution approaches used.
- Students can implement and validate automation solutions in various development environments (e.g. MATLAB/ Simulink, ROS, …). They are further able to apply their solutions across various system boundaries (e.g. automation concepts on Windows, ROS on Linux)
- Students gain insights into various engineering disciplines (e.g. mechanical engineering) and in rapid prototyping processes
- Students are able to use industrial bus systems (e.g. EtherCAT) in an automation context
- Students are able to apply methods that they have previously acquired in lectures on automation, control and robotics

Content
This module is designed to teach students the stated qualification objectives in the fields of automation, robotics and control by means of a complex automation task. The task not only covers the automation concept itself but also underlying aspects like hardware design, communication using an industrial bus system, drive system control and others. To do so, laboratory systems, namely laboratory scale robotic manipulator arms, are provided to the students.

Module Grade Calculation
The module grade results of the assessment of the pitches, presentation and the oral exam. Details will be given during the lecture at the beginning of the semester.

Additional Information
Due to capacity reasons there are only 25 places available. If necessary, a selection procedure will be carried out. Selection criteria are the progress in studies and in the recommended lectures. The application window is from March 1 for March 31 in Campus Plus (https://plus.campus.kit.edu/). For further information and current news, regularly visit the courses website (https://www.irs.kit.edu/Lectures_5404.php).

Workload

1. Introduction to the test stand (15h)
2. Introduction to single-axis motor control (15h)
3. Construction and print of end-effector components (30h)
4. Introduction to ROS (15h)
5. Implementation of hardware-interfaces in ROS (30h)
6. Automation, motion planning and control (30h)
7. Implementation on the real robot (15h)
8. Presentations and preparation (15h)
9. Oral exam and preparation (15h)

A total of 180 h = 6 CR

Recommendations
Knowledge in automation, control and robotics in general.

Teaching and Learning Methods
LACR – Laboratory Automation Control & Robotics (4 SWS)

M 4.51 Module: Simulation of Fluid Separation Processes [M-CIWVT-106965]

Coordinators: Prof. Dr.-Ing. Tim Zeiner
Organisation: KIT Department of Chemical and Process Engineering
Part of: Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-113924	Simulation of Fluid Separation Processes		**6 CP**	**Zeiner**

Assessment
Learning control is an examination of another type: The students independently carry out a simulation project of a thermal separation process in a commercial process simulator.

Prerequisites
None

Competence Goal
Students will be able to

- explain the fundamentals of constructing stationary and dynamic process flow diagrams
- apply methods for calculating thermodynamic variables and transport variables
- analyze and optimize complex processes
- analyze the structure of flow diagrams and their initialization

Content
Steady-state and dynamic simulations, flowsheet simulations, algorithms for solving steady-state and dynamic flowsheets, design specifications, improvement of convergence behaviour, interpretation of results, use of common flowsheet simulators.

Module Grade Calculation
The module grade is the grade of the examination of another type.

Workload

- Attendance time/ lectures: 60 hrs
- Preparation and wrap-up lectures: 60 hrs
- Exam preparation: 60 hrs

Recommendations
Basic knowledge in Fluid Separations.

M 4.52 Module: Statistical Thermodynamics [M-CIWVT-107779]

Coordinators: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	2

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-106098	Statistical Thermodynamics		6 CP	Enders

Assessment
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
None.

Competence Goal
students will be able to

- explain and apply the basic principles of statistical mechanics (Boltzmann and Gibbs methods),
- establish the connection between microscopic properties and macroscopic material properties,
- develop and apply equations of state and activity coefficient models for complex material systems, and evaluate their advantages and disadvantages in process engineering.

Content
Boltzmann-method, Gibbs-method, real gases, quations of state, polymers

Module Grade Calculation
The module grade is the grade of the oral exam.

Additional Information
In consultation with the students, the lecture may also be conducted in German.

Workload

- Lectures and exercises: 60 hrs
- Homework, wrap-up of lectures and exercises: 60 hrs
- Exam preparation: 60 hrs

Literature

- J. Blahous, Statistische Thermodynamik, Hirzel Verlag Stuttgart, 2007.
- H.T. Davis, Statistical Mechanics of Phases, Interfaces, and Thin Films, Wiley-VCH, New York, 1996.
- G.G, Gray, K.E. Gubbins, Theory of Molecular Fluids Fundamentals. Clarendon, Press Oxford, 1984.
- J.P. Hansen, I.R. McDonald, Theory of Simple Liquids with Application to Soft Matter. Fourth Edition, Elsevier, Amsterdam, 2006.
- G.H. Findenegg, T. Hellweg, Statistische Thermodynamik, 2. Auflage,
- Springer Verlag, 2015.
- J.O. Hirschfelder, C.F. Curtis, R.B. Bird, Molecular Theory of Gases and Liquids. John-Wiley & Sons, New York, 1954.

4.53 Module: Technology and Society [M-MACH-106944]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering
Part of: Interdisciplinary Electives

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	pass/fail	Each term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Technology and Society (Elective: at least 4 credits)				
T-GEISTSOZ-115108	Energy Ethics	ST	2 CP	Frigo
T-GEISTSOZ-115075	Foundations of Technology Ethics	ST	2 CP	Derpmann
T-GEISTSOZ-115018	History of Technology and the Environment for Mechanical Engineering Students	ST	4 CP	Popplow
T-MACH-113883	Introduction to Philosophy of Technology	WT	2 CP	Hillerbrand
T-MACH-114962	Introduction to Philosophy of Technology - Essay		1 CP	Hillerbrand
T-MACH-114961	Introduction to Philosophy of Technology - Homework		1 CP	Hillerbrand
T-FORUM-113972	Scientific Literacy. Between “Follow the Science” and “Do Your Own Research” A Basic Seminar on the Relation Between Science and Society		2 CP	
T-MACH-113884	Technology Assessment and its Normative Basis	WT	2 CP	Hillerbrand

Assessment
Depending on individual choice.

Prerequisites
none

Competence Goal
In this module, students gain an understanding of the interplay between technology and society. They are enabled to assess, critically question and evaluate the consequences of their decisions and actions on society and the environment, thus acquiring ethical reflection skills. For example, they can determine the benefits and risks of new technologies and carry out a technology assessment, recognize the emergence of innovation and communicate science and research with various groups from outside the field.

Content
Depending on individual choice.

Module Grade Calculation
The module is ungraded.

Workload
120 hours, corresponding to 4 CP.

This corresponds to 30 hours of attendance time and 90 hours of self-study time for a course of 2 SWS (90 minutes per week).

M 4.54 Module: Theory of Stability [M-MACH-107108]

Coordinators: Prof. Dr.-Ing. Alexander Fidlin
Organisation: KIT Department of Mechanical Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-MACH-105372	Theory of Stability	**ST**	**6 CP**	**Fidlin**

Assessment
see course

Prerequisites
none

Competence Goal
Students receive an overview of typical mechanisms of instability in oscillatory systems. They can distinguish between stability, asymptotic stability and orbital stability. They learn the most important methods for analyzing stability in dynamics, including eigenvalue analysis and the direct Lyapunov method, and can apply these procedures in practice-relevant cases. Students learn methods of stabilizing movements including gyroscopic stabilization and stabilization through high-frequency excitation and can apply corresponding concepts.

Content

- Basic concepts of stability
- Lyapunov functions
- Direct Lyapunov method
- Stability of the equilibrium position
- Catchment area of a stable solution
- Stability after the first approximation
- Systems with parametric excitation
- Stability criteria in control engineering

Module Grade Calculation
The module grade corresponds to the grade of the exam.

Workload
Total: 180 hours, of which 60 hours attendance, 120 hours self-study

M 4.55 Module: Thermal Process Engineering II [M-CIWVT-107039]

Coordinators: Prof. Dr.-Ing. Tim Zeiner
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	German	5	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-114107	Thermal Process Engineering II		**6 CP**	**Zeiner**

Assessment
Leaning control is a written examination lasting 180 minutes.

Prerequisites
None

Competence Goal
Students are able to independently evaluate and model processes for separating mixtures of substances. They can also optimize these unit operations for specific separations.

Content
The lecture covers the extension of basic thermal operations. Drying, membrane processes, and chromatography as separation methods are introduced. In addition, the rectification of real systems and multi-component rectification are considered. Furthermore, crystallization is explored in greater depth. Another focus is on process intensification and synthesis in order to make processes more efficient and resource-friendly. Finally, possibilities for process simulation are presented.

Module Grade Calculation
The module grade ist the grade of the written exam.

Workload

- Lectures and exercises: 45 hrs
- Homework: 90 hrs
- Exam preparation: 45 hrs

M 4.56 Module: Thermodynamics [M-CIWVT-106964]

Coordinators: Prof. Dr. Sabine Enders
Prof. Dr. Dr. Michael Fischlschweiger

Organisation: KIT Department of Chemical and Process Engineering

Part of: Core Competencies

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-113923	Advanced Thermodynamics		**6 CP**	**Enders, Fischlschweiger**

Assessment
The learning control is an oral examination, duration approx. 30 minutes.

Prerequisites
None

Competence Goal
students will be able to:

- apply the first and second laws of thermodynamics to complex technical systems,
- describe and evaluate thermodynamic state variables of complex mixtures using suitable models,
- analyze reversible and irreversible state changes and assess their efficiency,
- identify and critically reflect on model limitations and open questions.

Content

- Balancing of material and energy for complex processes in engineering science,
- Calculation of reversible and irreversible change of states
- Selection of thermodynamic models for the description of physical properties
- Analysis and optimization of complex process

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload

- Attendance time/ lectures: 60 hrs
- Preparation and wrap-up lectures: 60 hrs
- Exam preparation: 60 hrs

Recommendations
Basic knowledge about first and second law of thermodynamics.

M 4.57 Module: Thermodynamics of Interfaces [M-CIWVT-107780]

Coordinators: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: Methods

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-CIWVT-106100	Thermodynamics of Interfaces	**ST**	**6 CP**	**Enders**

Assessment
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
None

Competence Goal
The students to be familiar with the peculiarities on fluid-fluid and fluid-solid interfacial properties. They are able to calculate interfacial properties (interfacial tension, density - and concentration profils, adsorption isotherms) using macroscopic and local-dependent methods.

Content
Gibbs-method, density functional theory, experimental methods for characterization of interfaces, adsorption

Module Grade Calculation
The module grade is the grade of the oral exam.

Additional Information
In consultation with the students, the lecture may also be conducted in German.

Workload

- Lectures and exercises: 45 h
- Homework: 90 h
- Exam preparation: 45 h

M 4.58 Module: Wave Propagation in Solids [M-BGU-107916]

Coordinators: Prof. Dr.-Ing. Thomas Seelig
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: Methods
Computational Engineering and Applications

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	1

ID	Name	Term offered	Credits	Lecturers
Mandatory				
T-BGU-115430	Homework 'Wave Propagation in Solids'	**ST**	**1 CP**	**Seelig**
T-BGU-115337	Wave Propagation in Solids	**WT+ST**	**3 CP**	**Seelig**

Assessment
- module component T-BGU-115430 with examination of another type according to § 4 Par. 2 No. 3
- module component T-BGU-115337 with oral examination according to § 4 Par. 2 No. 2

details about the learning control, see module component

Prerequisites
none

Competence Goal
Students are familiar with the dynamic behavior of deformable solids and structures in the form of traveling and standing waves. They are able to describe relevant engineering problems using continuum mechanics and apply mathematical solution methods.

Content

- 1D wave propagation in rods and beams (derivation of the wave equations)
- Bernoulli's and d'Alembert's solution methods for standing and travelling waves
- 3D wave propagation in elastic continua (plane waves, spherical waves, surface waves)
- reflection and refraction at interfaces
- aspects of nonlinear wave propagation

Module Grade Calculation
grade of the module is CP weighted average of grades of the partial exams

Additional Information
The modul will be offered as from winter term 2026/27.

The course 'Wave Propagation in Solids' will be offered fo rthe first time in summer term 2027.

Workload
contact hours (1 HpW = 1 h x 15 weeks):

- lecture: 30 h

independent study:

- preparation and follow-up lectures: 30 h
- preparation of the homework (partial examination): 30 h
- examination preparation (partial examination): 30 h

total: 120 h

Recommendations
basic knowledge of continuum mechanics and partial differential equations

Literature
Achenbach, J.D.: Wave Propagation in Elastic Solids. North Holland, 1973Bedford, A., Drumheller, D.S.: Introduction to Elastic Wave Propagation. Wiley, 1994
Hagedorn, P., DasGupta, A.: Vibrations and Waves in Continuous Mechanical Systems. Wiley, 2007

5 Module components

5.1 Module component: Model Development and Simulation in Thermal Process Engineering [T-CIWVT-113702]

Coordinators: Prof. Dr.-Ing. Tim Zeiner
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106832 - Model Development and Simulation in Thermal Process Engineering

Type	Credits	Grading	Version
Examination of another type	6 CP	graded	1

Courses					
WT 26/27	**2260160**	Model Development and Simulation in Thermal Process Engineering	**2 SWS**	**Lecture / 🗣**	**Zeiner**
WT 26/27	**2260161**	Exercises on 2260160 Model Development and Simulation in Thermal Process Engineering	**2 SWS**	**Practice / 🗣**	**Zeiner, und Mitarbeitende**

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Learning control is an examination of another type. Term paper (max 30 pages) and presentation (duration approx. 20 minutes).

Prerequisites
None.

Additional Information
If required, the course will be offered in English.

T 5.2 Module component: Advanced Game Theory [T-WIWI-102861]

Coordinators: Prof. Dr. Karl-Martin Ehrhart
Prof. Dr. Clemens Puppe
Prof. Dr. Johannes Philipp Reiß

Organisation: KIT Department of Business and Economics

Part of: M-MACH-106946 - Economics and Law

Type	Credits	Grading	Term offered	Version
Written examination	4 CP	graded	Each winter term	3

Courses					
WT 26/27	2500037	Advanced Game Theory	2 SWS	Lecture / 🗣	Puppe, Ammann
WT 26/27	2500038	Übung zu Advanced Game Theory	1 SWS	Practice / 🗣	Puppe, Ammann

Legend: 🖥 Online, ✿ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
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.

Prerequisites
None

Recommendations
It is recommended that students have basic knowledge in mathematics and statistics.

Workload
120 hours

T 5.3 Module component: Advanced Methods in Nonlinear Process Control [T-CIWVT-113490]

Coordinators: Dr.-Ing. Pascal Jerono
Prof. Dr.-Ing. Thomas Meurer

Organisation: KIT Department of Chemical and Process Engineering

Part of: M-CIWVT-106715 - Advanced Methods in Nonlinear Process Control

Type	Credits	Grading	Term offered	Version
Oral examination	4 CP	graded	Each summer term	1

Courses					
ST 2026	2243035	Advanced Methods in Nonlinear Control	2 SWS	Lecture / 🗣	Meurer, Jerono

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.4 Module component: Advanced Thermodynamics [T-CIWVT-113923]

Coordinators: Prof. Dr. Sabine Enders
Prof. Dr. Dr. Michael Fischlschweiger
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106964 - Thermodynamics

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Courses					
WT 26/27	2250070	Advanced Thermodynamics	2 SWS	Lecture / 🗣	Enders, Fischlschweiger
WT 26/27	2250071	Exercises on 2250070 Advanced Thermodynamics	2 SWS	Practice / 🗣	Enders, Fischlschweiger

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None

T 5.5 Module component: Artificial Intelligence in Service Systems [T-WIWI-108715]

Coordinators: Prof. Dr. Gerhard Satzger
Organisation: KIT Department of Business and Economics
Part of: M-MACH-106946 - Economics and Law

Type	Credits	Grading	Term offered	Version
Written examination	4 CP	graded	Each winter term	3

Courses					
WT 26/27	**2595650**	Artificial Intelligence in Service Systems	**1.5 SWS**	**Lecture /**	**Spitzer, Holstein, Satzger**
WT 26/27	**2595651**	Übung zu Artificial Intelligence in Service Systems	**1.5 SWS**	**Practice /**	**Spitzer, Holstein, Hendriks, Satzger**

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Assessment
The assessment consists of a written exam (60 min). Successful completion of the exercises is a prerequisite for admission to the written exam.

Prerequisites
None

Additional Information
The course will be offered in the form of a flipped classroom concept starting in winter semester 2022/2023. The lecture will be recorded in advance and made available online. During the exercise classes, the contents of the lecture will be discussed and applied as part of programming exercises.

Workload
120 hours

T 5.6 Module component: Basics of Finite Elements [T-BGU-115273]

Coordinators: Prof. Dr.-Ing. Peter Betsch
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-107079 - Computational Methods

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	5 CP	graded	Each term	1 semesters	1

Assessment
oral exam, appr. 30 min.

Prerequisites
none

Recommendations
none

Additional Information
will be offered newly as from winter term 2026/27 in English

courses:

- Basics of Finite Elements; lecture, 2 HpW/SWS, summer term
- Exercise Basics of Finite Elements; exercise, 2 HpW/SWS, summer term

Workload
150 hours

T 5.7 Module component: Business Innovation in Optics and Photonics [T-ETIT-104572]

Coordinators: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-MACH-106946 - Economics and Law

Type	Credits	Grading	Term offered	Version
Examination of another type	4 CP	graded	Each winter term	2

Courses					
WT 26/27	2305742	Business Innovation in Optics and Photonics	2 SWS	Lecture / 🗣	Riedel, Nahm
WT 26/27	2305743	Erxercise for 2305742 Business Innovation in Optics and Photonics	1 SWS	Practice / 🗣	Riedel, Nahm

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Type of Examination: examination of another type

Duration of Examination: 4 group presentations à 20 minutes (approx.)

Modality of Exam: The exam consists of four group presentations. 2nd day: Technology Presentation. 3rd day: Development plan presentation. 4th day: Business Canvas presentation. Final presentation: Business pitch. The overall impression is rated.

Prerequisites
none

Recommendations
Good knowledge in optics & photonics. Personal motivation and interest for getting deeper into business development aspects, methods and tools. Commitment to active, regular and coninuous participation in the group work.

T 5.8 Module component: Computational Contact Mechanics [T-BGU-115276]

Coordinators: Dr.-Ing. Marlon Franke
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-107859 - Computational Contact Mechanics

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	6 CP	graded	Each term	1 semesters	1

Assessment
oral exam, appr. 30 min.

Prerequisites
none

Recommendations
none

Additional Information
will be offered newly as from winter term 2026/27 in English

courses:

- Contact Mechanics; lecture/exercise, 4 HpW/SWS, summer term

Workload
180 hours

T 5.9 Module component: Computational Elasticity [T-MACH-113989]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Dr.-Ing. Tom-Alexander Langhoff

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107094 - Computational Elasticity

Type	Credits	Grading	Term offered	Version
Oral examination	5 CP	graded	Each winter term	2

Courses					
WT 26/27	2161250	Computational Elasticity	2 SWS	Lecture / 🗣	Langhoff, Böhlke

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
oral examination, approx. 30 min.

Prerequisites
Coursework in *Tutorial Computational Elasticity* (T-MACH-114529) must be passed

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module component T-MACH-114529 - Tutorial Computational Elasticity must have been passed.

Recommendations
Knowledge of the contents of the course "Nonlinear Continuum Mechanics" (T-MACH-111026) of the focus field "Computational and applied Mechanics" (M-MACH-106976) are recommended.

Additional Information
The corresponding course is offered in English. Further Information can be found in the course description "Computational Elasticity"

Workload
150 hours

T 5.10 Module component: Computational Fluid Dynamics and Simulation Lab [T-MATH-113373]

Coordinators: Prof. Dr. Martin Frank
PD Dr. Mathias Krause
Dr. Stephan Simonis
PD Dr. Gudrun Thäter

Organisation: KIT Department of Mathematics

Part of: M-MATH-106634 - Computational Fluid Dynamics and Simulation Lab

Type	Credits	Grading	Version
Examination of another type	4 CP	graded	1

Courses					
ST 2026	**0161700**	Computational Fluid Dynamics and Simulation Lab	**4 SWS**	**Practical course**	**Thäter, Krause, Simonis**

Prerequisites
none

Workload
120 hours

T 5.11 Module component: Computational Inelasticity [T-MACH-113990]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Dr.-Ing. Tom-Alexander Langhoff

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107095 - Computational Inelasticity

Type	Credits	Grading	Term offered	Version
Oral examination	5 CP	graded	Each summer term	2

Courses					
ST 2026	2162296	Computational Inelasticity	2 SWS	Lecture / 🗣	Böhlke, Langhoff

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
oral examination, approx. 30 min.

Prerequisites
Coursework in *Tutorial Computational Inelasticity* (T-MACH-114530) must be passed

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module component T-MACH-114530 - Tutorial Computational Inelasticity must have been passed.

Recommendations
Knowledge of the contents of the course "Nonlinear Continuum Mechanics" (M- MACH-107110) as well as of "Computational Elasticity" (M-MACH-107094) are recommended.

Additional Information
The corresponding course is offered in English. Further Information can be found in the course description "Computational Inelasticity"

Workload
150 hours

T 5.12 Module component: Computational Macroeconomics [T-WIWI-112723]

Coordinators: Prof. Dr. Johannes Brumm
Organisation: KIT Department of Business and Economics
Part of: M-MACH-106946 - Economics and Law

Type	Credits	Grading	Term offered	Version
Written examination	4 CP	graded	Each summer term	3

Courses					
ST 2026	2500162	Computational Macroeconomics	2 SWS	Lecture / 🗣	Schang, Brumm
ST 2026	2500164	Übung zu Computational Macroeconomics	1 SWS	Practice / 🗣	Schang

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
This component will no longer be offered starting from the winter semester 27/28. The final opportunity to enroll and complete the assessment is the summer semester 27.

The assessment takes place in the form of a written 60 min. examination during the lecture-free period of the semester. The examination is offered every semester and can be repeated at any regular examination date.

Prerequisites
None

Workload
120 hours

T 5.13 Module component: Computational Mechanics of Materials [T-MACH-113939]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-106947 - Mechanics

Type	Credits	Grading	Term offered	Version
Written examination	4 CP	graded	Each winter term	2

Courses					
WT 26/27	**2161254**	Computational Mechanics of Materials	**2 SWS**	**Lecture /**	**Böhlke**

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Assessment
Written examination, duration: 90 minutes

Prerequisites
none

Recommendations
none

Additional Information
The corresponding course is offered in English. Further Information can be found in the course description 2161259 "Computational Mechanics of Materials"

Workload
120 hours

T 5.14 Module component: Computational Structural Dynamics [T-BGU-115275]

Coordinators: Prof. Dr.-Ing. Peter Betsch
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-107858 - Computational Structural Dynamics

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	6 CP	graded	Each term	1 semesters	1

Assessment
oral exam, appr. 30 min.

Prerequisites
none

Recommendations
none

Additional Information
will be offered newly as from winter term 2026/27 in English

courses:

- Computational Structural Dynamics; lecture/exercise, 4 HpW/SWS, summer term

Workload
180 hours

T 5.15 Module component: Computer-Aided Reactor Design [T-CIWVT-113667]

Coordinators: Prof. Dr.-Ing. Gregor Wehinger
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106809 - Computer-Aided Reactor Design

Type	Credits	Grading	Version
Examination of another type	6 CP	graded	1

Courses					
WT 26/27	**2220070**	Computer-Aided Reactor Design	**1 SWS**	**Lecture / 🗣**	**Kutscherauer, Wehinger**
WT 26/27	**2220071**	Exercises on 2220070 Computer-Aided Reactor Design	**2 SWS**	**Practice / 🗣**	**Kutscherauer, Hahn, Wehinger**

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Learning control is an examination of another type:
The project assignment will be evaluated based on the source code, the poster, and its presentation.

Prerequisites
None.

T 5.16 Module component: Cyber-Physical Modeling [T-ETIT-113908]

Coordinators: Prof. Dr.-Ing. Mike Barth
Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106953 - Cyber-Physical Modeling

Type	Credits	Grading	Version
Written examination	6 CP	graded	1

Courses					
ST 2026	**2303310**	Cyber Physical Modeling	**3 SWS**	**Lecture / 🗣**	**Hohmann, Barth**
ST 2026	**2303311**	Tutorial to 2303310 Cyber Physical Modeling	**1 SWS**	**Practice / 🗣**	**Hohmann, Barth, Thömmes, Schicketanz**

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The examination takes place in the form of a written examination lasting 90 min.
The module grade is the grade of the written exam.

Prerequisites
none

T 5.17 Module component: Data and Artificial Intelligence for Numerical Simulations [T-MACH-113926]

Coordinators: Dr. Anastasia August
Dr.-Ing. Arnd Koeppe
Organisation: KIT Department of Mechanical Engineering
Part of: M-MACH-107450 - Data and Artificial Intelligence for Numerical Simulations

Type	Credits	Grading	Term offered	Version
Examination of another type	4 CP	graded	Each summer term	3

Courses					
ST 2026	2182222	Data and Artificial Intelligence for Numerical Simulations	4 SWS	Lecture / Practice /	Koeppe, August

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Assessment
Written report and oral examination/presentation (about 20 minutes)

Prerequisites
The course requires a *good foundation in (continuum) mechanics* or *numerical simulations*. **One of the following courses (or equivalent) must be completed successfully**

- Computational Mechanics of Materials [T-MACH-113939]
- Fluid Mechanics of Turbulent Flows [T-BGU-110841]
- Mathematical Methods in Fluid Mechanics [T-MACH-113956]
- Nonlinear Continuum Mechanics [T-MACH-111026]
- Computational Elasticity [T-MACH-113989]
- Computational Inelasticity [T-MACH-113990]

Recommendations
Python experience

Additional Information
The course is offered in English. Please register via Campus+ within the first two classroom weeks of the semester.

Workload
120 hours

T 5.18 Module component: Data-Based Modeling and Control [T-CIWVT-112827]

Coordinators: Prof. Dr.-Ing. Thomas Meurer
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106319 - Data-Based Modeling and Control

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Courses					
WT 26/27	2243070	Data-Based Modeling and Control	3 SWS	Lecture / Practice / 🗣	Meurer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.19 Module component: Deep Learning for Engineers [T-MACH-113882]

Coordinators: Prof. Dr.-Ing. Christoph Stiller
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107088 - Deep Learning for Engineers

Type	Credits	Grading	Term offered	Expansion	Version
Written examination	6 CP	graded	Each summer term	1 semesters	2

Courses					
ST 2026	2138335	Deep Learning for Engineers	2 SWS	Lecture / 🗣	Stiller, Lauer, Pauls, Rösch
ST 2026	2138337	Deep Learning for Engineers (Tutorial)	1 SWS	Practice / 🗣	Stiller, Lauer, Pauls, Rösch, Wang

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
written exam

60 min

Prerequisites
none

Additional Information
The course is offered in English

Workload
180 hours

T 5.20 Module component: Digital Real Time Simulations for Energy Technologies [T-ETIT-113449]

Coordinators: Prof. Dr.-Ing. Giovanni De Carne
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106690 - Digital Real Time Simulations for Energy Technologies

Type	Credits	Grading	Version
Examination of another type	3 CP	graded	1

Courses					
ST 2026	2314013	Digital Real Time Simulations for Energy Technologies	2 SWS	Lecture / 🗣	De Carne

Legend: 🖥 Online, ✱ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The examination takes place in form of other types of examination. It consists of an assessment from an exercise on HiL and an oral overall examination (approx. 15 minutes) explaining the exercise results. The overall impression is evaluated.
The module grade results of the assessment of an exercise and the oral exam. Details will be given during the lecture.

Prerequisites
none

T 5.21 Module component: Energy Ethics [T-GEISTSOZ-115108]

Coordinators: Dr. Giovanni Frigo
Organisation: KIT Department of Humanities and Social Sciences
Part of: M-MACH-106944 - Technology and Society

Type	Credits	Grading	Term offered	Version
Coursework	2 CP	pass/fail	Each summer term	1

Courses					
ST 2026	5000005	Energy Ethics	2 SWS	Seminar	Frigo

Assessment
Academic achievements in the form of written assignments and/or oral performances.

Prerequisites
keine

Additional Information
The course is offered in English.

Workload
60 hours

T 5.22 Module component: Entrepreneurship [T-WIWI-102864]

Coordinators: Prof. Dr. Orestis Terzidis
Organisation: KIT Department of Business and Economics
Part of: M-MACH-106946 - Economics and Law

Type	Credits	Grading	Term offered	Version
Written examination	4 CP	graded	Each term	2

Courses					
ST 2026	2545001	Entrepreneurship	2 SWS	Lecture / 🗣	Terzidis, Dang
WT 26/27	2545001	Entrepreneurship	2 SWS	Lecture / 🧩	Terzidis, Dang

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment consists of a written exam (60 minutes) (following §4(2), 1 of the examination regulation).

Students are offered the opportunity to earn a grade bonus through separate assignments. If the grade of the written exam is between 4.0 and 1.3, the bonus improves the grade by a maximum of one grade level (0.3 or 0.4). The exact criteria for awarding a bonus will be announced at the beginning of the lecture.

Prerequisites
None

Recommendations
None

Workload
120 hours

T 5.23 Module component: Estimator and Observer Design [T-CIWVT-112828]

Coordinators: Dr.-Ing. Pascal Jerono
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106320 - Estimator and Observer Design

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Courses					
WT 26/27	2243110	Estimator and Observer Design	3 SWS	Lecture / Practice / 🗣	Jerono

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None

T 5.24 Module component: Finite Elements in Solid Mechanics [T-BGU-115274]

Coordinators: Prof. Dr.-Ing. Peter Betsch
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-107857 - Finite Elements in Solid Mechanics

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	6 CP	graded	Each term	1 semesters	1

Assessment
oral exam, appr. 30 min.

Prerequisites
none

Recommendations
none

Additional Information
will be offered newly as from winter term 2026/27 in English

courses:

- Finite Elements in Solid Mechanics; lecture, 2 HpW/SWS, for the first time WiSe 27/28
- Exercise Finite Elements in Solid Mechanics; exercise, 2 HpW/SWS, for the first time WiSe 27/28

Workload
180 hours

T 5.25 Module component: Fluid Mechanics of Turbulent Flows [T-BGU-110841]

Coordinators: Prof. Dr.-Ing. Markus Uhlmann
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-105361 - Fluid Mechanics of Turbulent Flows

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	6 CP	graded	Each term	1 semesters	1

Courses					
ST 2026	6221806	Fluid Mechanics of Turbulent Flows	4 SWS	Lecture / Practice / 🗣	Uhlmann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
oral exam, appr. 45 min.

Prerequisites
none

Recommendations
none

Additional Information
none

Workload
180 hours

T 5.26 Module component: Foundations of Technology Ethics [T-GEISTSOZ-115075]

Coordinators: Dr. phil. Simon Derpmann
Organisation: KIT Department of Humanities and Social Sciences
Part of: M-MACH-106944 - Technology and Society

Type	Credits	Grading	Term offered	Version
Coursework	2 CP	pass/fail	Each summer term	1

Courses					
ST 2026	5000010	Introduction to the Ethics of Technology and Responsible Engineering	2 SWS	Course	Derpmann

Assessment
The course is assed through a written in-person exam lasting 60 minutes.

Prerequisites
T-ETIT-111923 – Technikethik - ARs ReflecTIonis must not have been started.

Additional Information
The course is offered in English.

Learning objectives: Engineering decisions shape lives, institutions, and ecosystems—yet they are rarely value-neutral. This course trains students to identify and critically analyze the ethical dimensions of technological systems, reconstruct and evaluate moral arguments, and navigate value conflicts in engineering practice. Through structured debates, they develop the capacity to justify coherent positions and articulate the responsibilities of engineers, firms, and institutions toward society.

Upon completion students are prepared to critically engage with ethical and political challenges in technology—in professional practice, public discourse, and their own role in shaping a responsible technological future.

Workload
60 hours

T 5.27 Module component: Fracture and Damage Mechanics [T-BGU-115277]

Coordinators: Prof. Dr.-Ing. Thomas Seelig
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-107860 - Fracture and Damage Mechanics

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	6 CP	graded	Each term	1 semesters	1

Courses					
WT 26/27	6215903	Fracture and Damage Mechanics	2 SWS	Lecture / 🗣	Seelig
WT 26/27	6215904	Exercises Fracture and Damage Mechanics	2 SWS	Practice / 🗣	Seelig

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
oral exam, appr. 45 min.

Prerequisites
none

Recommendations
none

Additional Information
will be offered newly as from winter term 2026/27 in English

Workload
180 hours

T 5.28 Module component: Heat and Mass Transfer [T-MACH-114099]

Coordinators: Prof. Dr. Dr. Michael Fischlschweiger
Dr.-Ing. Chunkan Yu

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107850 - Heat and Mass Transfer

Type	Credits	Grading	Term offered	Version
Written examination	4 CP	graded	Each summer term	2

Courses					
ST 2026	3122512	Heat and Mass Transfer	2 SWS	Lecture / 🗣	Fischlschweiger, Yu
ST 2026	3122513	Heat and Mass Transfer (Excercises)	2 SWS	Practice / 🗣	Fischlschweiger, Yu

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Written exam, 3 h

Prerequisites
none

Workload
120 hours

T 5.29 Module component: History of Technology and the Environment for Mechanical Engineering Students [T-GEISTSOZ-115018]

Coordinators: Prof. Dr. Marcus Popplow
Organisation: KIT Department of Humanities and Social Sciences
Part of: M-MACH-106944 - Technology and Society

Type	Credits	Grading	Term offered	Version
Coursework	4 CP	pass/fail	Each summer term	1

Courses					
ST 2026	**5012014**	Science and Technology in 20th Century Wars	**2 SWS**	**Seminar / 🗣**	**Schauz**
ST 2026	**5012056**	History of Technology and the Environment for Mechanical Engineering Students (Seminar on Tuesday)	**2 SWS**	**Seminar / 🗣**	**Popplow**
ST 2026	**5012069**	History of Technology and the Environment for Mechanical Engineering Students (Seminar on Thursday))	**2 SWS**	**Seminar / 🗣**	**Popplow**

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Assessment
Mandatory for obtaining 4 CP are a) the weekly submission of short, informal comments on the topics to be worked on and b) in a meeting, usually in pairs, a short oral summary of the submissions and the leading of the corresponding discussion.

Prerequisites
none

Workload
120 hours

5.30 Module component: Homework 'Basics of Finite Elements' [T-BGU-115272]

Coordinators: Prof. Dr.-Ing. Peter Betsch
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-107079 - Computational Methods

Type	Credits	Grading	Term offered	Expansion	Version
Coursework	1 CP	pass/fail	Each summer term	1 semesters	1

Assessment
processing of three exercise sheets

Prerequisites
none

Recommendations
none

Additional Information
will be offered newly as from winter term 2026/27 in English

courses:

- Basics of Finite Elements; lecture, 2 HpW/SWS, summer term
- Exercise Basics of Finite Elements; exercise, 2 HpW/SWS, summer term

Workload
30 hours

T 5.31 Module component: Homework 'Wave Propagation in Solids' [T-BGU-115430]

Coordinators: Prof. Dr.-Ing. Thomas Seelig
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-107916 - Wave Propagation in Solids

Type	Credits	Grading	Term offered	Expansion	Version
Examination of another type	1 CP	graded	Each summer term	1 semesters	1

Assessment
processing of two exercise sheets

Prerequisites
none

Recommendations
none

Additional Information
will be offered for the first time in SoSe 2027

Workload
30 hours

T 5.32 Module component: Human Factors Engineering II (Organizational Design) [T-MACH-114176]

Coordinators: Prof. Dr.-Ing. Barbara Deml
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-106946 - Economics and Law

Type	Credits	Grading	Term offered	Version
Written examination	4 CP	graded	Each winter term	1

Courses					
WT 26/27	2109032	Human Factors Engineering II (Organizational Design)	2 SWS	Lecture / 🗣	Deml

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
written exam, 60 minutes

Prerequisites
none

Additional Information
The course is offered in English.

Workload
120 hours

T 5.33 Module component: Introduction to Multi-Body Dynamics [T-MACH-114755]

Coordinators: Prof. Dr.-Ing. Alexander Fidlin
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107485 - Introduction to Multi-Body Dynamics

Type	Credits	Grading	Term offered	Version
Written examination	8 CP	graded	Each summer term	2

Courses					
ST 2026	2162235	Introduction to Multi-Body Dynamics	3 SWS	Lecture / 🗣	Ströhle, Mukherjee

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
written examination, 180 min

Prerequisites
"T-MACH-105209 – Einführung in die Mehrkörperdynamik" must not have been started.

Additional Information
The course is offered in English.

Workload
240 hours

T 5.34 Module component: Introduction to Numerical Simulation of Reacting Flows [T-CIWVT-113436]

Coordinators: Prof. Dr. Oliver Thomas Stein
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106676 - Introduction to Numerical Simulation of Reacting Flows

Type	Credits	Grading	Version
Oral examination	3 CP	graded	2

Courses					
WT 26/27	**2232130**	Introduction to Numerical Simulation of Reacting Flows	**2 SWS**	**Lecture / 🗣**	**Stein**
WT 26/27	**2232131**	Introduction to Numerical Simulation of Reacting Flows - Exercises	**2 SWS**	**Practice / 🗣**	**Stein**

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The learning control ist an oral examination lasting approx. 30 minutes.

Prerequisites
The prerequisite must be passed before taking the oral examination.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module component T-CIWVT-113435 - Introduction to Numerical Simulation of Reacting Flows - Prerequisite must have been passed.

T 5.35 Module component: Introduction to Numerical Simulation of Reacting Flows - Prerequisite [T-CIWVT-113435]

Coordinators: Prof. Dr. Oliver Thomas Stein
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106676 - Introduction to Numerical Simulation of Reacting Flows

Type	Credits	Grading	Version
Coursework	5 CP	pass/fail	2

Courses					
WT 26/27	2232130	Introduction to Numerical Simulation of Reacting Flows	2 SWS	Lecture / 🗣	Stein
WT 26/27	2232131	Introduction to Numerical Simulation of Reacting Flows - Exercises	2 SWS	Practice / 🗣	Stein

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The learning control is a completed coursework: Reports on the tutorials documenting the processed task, the data generated and their analysis.

Prerequisites
None

T 5.36 Module component: Introduction to Philosophy of Technology [T-MACH-113883]

Coordinators: Prof. Dr. Dr. Rafaela Hillerbrand
Organisation: KIT Department of Mechanical Engineering
Part of: M-MACH-106944 - Technology and Society

Type	Credits	Grading	Term offered	Expansion	Version
Coursework	2 CP	pass/fail	Each winter term	1 semesters	3

Courses					
WT 26/27	5000046	Philosophical Foundations of Technology Assessment: An Introduction to Philosophy of Technology	2 SWS	Seminar / 🗣	Frigo

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Ungraded coursework in the form of a written assignment and presentation of a flipped classroom session.

Prerequisites
none

Additional Information
The course is offered in English

Workload
60 hours

T 5.37 Module component: Introduction to Philosophy of Technology - Essay [T-MACH-114962]

Coordinators: Prof. Dr. Dr. Rafaela Hillerbrand
Organisation: KIT Department of Electrical Engineering and Information Technology
KIT Department of Mechanical Engineering
Part of: M-MACH-106944 - Technology and Society

Type	Credits	Grading	Version
Coursework	1 CP	pass/fail	1

Courses					
WT 26/27	5000046	Philosophical Foundations of Technology Assessment: An Introduction to Philosophy of Technology	2 SWS	Seminar / 🗣	Frigo

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Ungraded coursework in the form of a written essay (approx. 3000 words) with at least six citations that compares and links two topics from the seminar

Prerequisites
The module components "T-MACH-113883 - Introduction to Philosophy of Technology" and "T-MACH-114961 - Introduction to Philosophy of Technology - Homework" must have been started.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module component T-MACH-113883 - Introduction to Philosophy of Technology must have been started.
2. The module component T-MACH-114961 - Introduction to Philosophy of Technology - Homework must have been started.

Workload
30 hours

T 5.38 Module component: Introduction to Philosophy of Technology - Homework [T-MACH-114961]

Coordinators: Prof. Dr. Dr. Rafaela Hillerbrand
Organisation: KIT Department of Electrical Engineering and Information Technology
KIT Department of Mechanical Engineering
Part of: M-MACH-106944 - Technology and Society

Type	Credits	Grading	Version
Coursework	1 CP	pass/fail	1

Courses					
WT 26/27	**5000046**	Philosophical Foundations of Technology Assessment: An Introduction to Philosophy of Technology	**2 SWS**	**Seminar / 🗣**	**Frigo**

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Assessment
Ungraded coursework in the form of written answers to questions and submission during the semester

Prerequisites
The module component "T-MACH-113883 - Introduction to Philosophy of Technology" must have been started.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module component T-MACH-113883 - Introduction to Philosophy of Technology must have been started.

Workload
30 hours

T 5.39 Module component: Machine Dynamics II [T-MACH-105224]

Coordinators: Prof. Dr.-Ing. Carsten Proppe
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107100 - Machine Dynamics II

Type	Credits	Grading	Term offered	Version
Oral examination	4 CP	graded	Each winter term	1

Courses					
ST 2026	2162220	Machine Dynamics II	2 SWS	Lecture / Online	Proppe
WT 26/27	2162220	Machine Dynamics II	2 SWS	Lecture / On-Site	Qi

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Assessment
oral exam, 20 min.

Prerequisites
none

Recommendations
Machine Dynamics

Additional Information
The course is offered in German/ English.

Workload
120 hours

T 5.40 Module component: Machine Learning and Uncertainty Quantification in Computational Mechanics [T-BGU-115229]

Coordinators: Prof. Dr.-Ing. Steffen Freitag
Dr. Ravi Ajitbhai Patel
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-107080 - Data Science

Type	Credits	Grading	Term offered	Expansion	Version
Examination of another type	6 CP	graded	Each summer term	1 semesters	1

Assessment
group project report, appr. 10 pages, presentation, appr. 15 min., with discussion, appr. 15 min.

Prerequisites
none

Recommendations
prior knowledge of python programming is advantageous but can be acquired during course work

Additional Information
will be offered newly as from winter term 2026/27

courses:

- Machine Learning in Computational and Structural Mechanics and Materials Modelling; lecture/exercise, 2 HpW/SWS, summer term
- Uncertainty quantification in Computational and Structural Mechanics and Materials Modelling; lecture/exercise, 2 HpW/SWS, summer term

Workload
180 hours

T 5.41 Module component: Master's Thesis [T-MACH-113931]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering
Part of: M-MACH-106969 - Master's Thesis

Type	Credits	Grading	Term offered	Version
Final Thesis	30 CP	graded	Each term	1

Assessment
(1a) The master's thesis module is assigned 30 credits. It consists of the master's thesis and a presentation. The presentation must be held six weeks after submission of the master's thesis at the latest.
(2) The master's thesis can be assigned by professors of KIT and habilitated members of the KIT Departments of Mechanical Engineering and of Chemical and Process Engineering. In addition, the examination committee can authorize other examiners according to Article 17, pars. 2 and 3 to assign the subject. The students are given the possibility of making proposals relating to the subject. If the master's thesis is to be written outside of the KIT Departments of Mechanical Engineering and of Chemical and Process Engineering, the approval of the examination committee is required. The master's thesis may also be accepted in the form of group work, if the contributions of the individual students to be evaluated in the examination can be distinguished clearly based on objective criteria and if the requirement outlined in par. 4 is fulfilled. In exceptional cases, the chairperson of the examination committee takes care of the student receiving a subject for the master's thesis within four weeks upon her/his request. In this case, the subject is issued by the chairperson of the examination committee.

(3) The subject, task, and scope of the master's thesis is limited by the supervisor such that it can be handled with the expenditure outlined in par. 4.

(4) The master's thesis demonstrates that the students are able to deal with a problem of their subject area in an independent manner and within a limited period of time using scientific methods. The scope of the master's thesis corresponds to 30 credits. The maximum duration of work on the thesis is six months. The subject and task must be adapted to the scope envisaged. The examination committee specifies the languages in which the master's thesis can be written. At the student's request, the examiner may agree to the master's thesis being written in a language other than English.

(5) When submitting the master's thesis, the students assure in writing that the thesis is original work by them alone and that they have used no sources and aids other than indicated, marked all citations in word and content, and observed the Statutes of KIT for Safeguarding Good Research Practice, as amended. If this declaration is not contained, the thesis will not be accepted. The wording of the declaration is: "Ich versichere wahrheitsgemäß, die Arbeit selbstständig verfasst, alle benutzten Quellen und Hilfsmittel vollständig und genau angegeben und alles kenntlich gemacht zu haben, was aus Arbeiten anderer unverändert oder mit Abänderungen entnommen wurde sowie die Satzung des KIT zur Sicherung guter wissenschaftlicher Praxis in der jeweils gültigen Fassung beachtet zu haben." (I herewith declare that the present thesis is original work written by me alone and that I have indicated completely and precisely all sources and aids used as well as all citations, whether changed or unchanged, of other theses and publications, and that I have observed the Statutes of KIT for Safeguarding Good Research Practice, as amended). If the declaration is found to be not true, the master's thesis will be evaluated "nicht ausreichend" (5.0, failed).

(6) The time of assignment of the subject of the master's thesis is recorded by the supervisor and the student/s and documented in the files of the examination committee four weeks after the start of work on the master's thesis at the latest.
The master's thesis must be submitted to the examination committee in secure digital form corresponding to the state of the art. The details, in particular the digital forms permitted for submission, are specified in the module handbook. The time of submission of the master's thesis is recorded in the files by the examination committee. If requested by the examiner, an additional printed version of the master's thesis must be submitted to the latter. In this case, the student must assure that the version submitted in digital form is identical with the printed copy.
The student is allowed to return the subject of the master's thesis once only within the first month of the period of work on the thesis. At the justified request of the student, the examination committee may extend the time of work on the thesis given in par. 4 by three months at the maximum. If the master's thesis is not submitted on time, it is deemed to have been "nicht ausreichend" (5.0, failed), unless the student is not responsible for this failure.

(7) The master's thesis is evaluated by a professor of KIT at least or by a habilitated member of the KIT Departments of Mechanical Engineering and of Chemical and Process Engineering and another examiner. As a rule, one of the examiners is the person who assigned the thesis according to par. 2. In case of deviating evaluations of both persons, the examination committee fixes the grade of the master's thesis within the limits of the evaluations of both persons. It may also appoint another expert. Evaluation will be made after the presentation; the evaluation period must not exceed eight weeks upon submission of the master's thesis.

Prerequisites
The requirement for admission to the master thesis module are 74 ECTS. As to exceptions, the examination board decides on a request of the student (see § 14 (1) SPO).

Modeled Prerequisites
The following conditions have to be fulfilled:

1. You need to have earned at least 74 credits in your study program.

Final Thesis
This module component represents a final thesis. The following periods have been supplied:

Submission deadline	6 months
Maximum extension period	3 months
Correction period	8 weeks

Workload
900 hours

T 5.42 Module component: Mathematical Methods in Fluid Mechanics [T-MACH-113956]

Coordinators: Prof. Dr.-Ing. Bettina Frohnapfel
Dr.-Ing. Davide Gatti

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107687 - Mathematical Methods in Fluid Mechanics

Type	Credits	Grading	Term offered	Version
Written examination	6 CP	graded	Each winter term	4

Courses					
WT 26/27	2154540	Mathematical Methods in Fluid Mechanics	4 SWS	Lecture / Practice / 🙡	Gatti, Frohnapfel

Legend: 🖥 Online, 🙡 Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Assessment
written examination - 90 minutes

Prerequisites
T-MACH-105295 and T-MACH-113955 must not have been started.

Recommendations
Basic Knowledge about Fluid Mechanics

Additional Information
The course is offered in English.

Workload
180 hours

T 5.43 Module component: Modeling of Polymer and Suspension Flows for Industrial Manufacturing Processes [T-MACH-114949]

Coordinators: Prof. Dr.-Ing. Luise Kärger
Dr.-Ing. Florian Wittemann

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107102 - Modeling of Polymer and Suspension Flows for Industrial Manufacturing Processes

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	4 CP	graded	Each summer term	1 semesters	1

Courses					
ST 2026	2114104	Modeling of Polymer and Suspension Flows for Industrial Manufacturing Processes	2 SWS	Lecture / 🗣	Wittemann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Assessment
Oral exam, duration approx. 20 minutes

Prerequisites
"T-MACH-113367 – Modellierung von Polymer- und Suspensionsströmungen für industrielle Fertigungsprozesse" not started

"T-MACH-114002Technologies and Simulation for Composites in Mass Production" not started

" T-MACH-114004 Prozesssimulationsmethoden für Faserverbunde" not started

Additional Information
The course is offered in English.

Workload
120 hours

T 5.44 Module component: Modeling of Turbulent Flows - RANS and LES [T-BGU-110842]

Coordinators: Prof. Dr.-Ing. Markus Uhlmann
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-105362 - Modeling of Turbulent Flows - RANS and LES

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	6 CP	graded	Each term	1 semesters	1

Courses					
WT 26/27	**6221911**	Modelling of Turbulent Flows - RANS and LES	**4 SWS**	**Lecture / Practice / 🗣**	**Uhlmann, Herlina**

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Assessment
oral exam, appr. 45 min.

Prerequisites
none

Recommendations
none

Additional Information
none

Workload
180 hours

T 5.45 Module component: Multiscale and Multiphysics Modeling for Porous Building Materials [T-BGU-115230]

Coordinators: Dr. Ravi Ajitbhai Patel
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-107828 - Multiscale and Multiphysics Modeling for Porous Building Materials

Type	Credits	Grading	Term offered	Expansion	Version
Examination of another type	6 CP	graded	Each summer term	1 semesters	1

Assessment
implementation of a case study, presentation, appr. 15 min., with discussion, appr. 20 min.

Prerequisites
none

Recommendations
none

Additional Information
will be offered newly as from winter term 2026/27

courses:

- Multiscale and Multiphysics Modeling for Porous Building Materials; lecture/exercise, 4 HpW/SWS, summer term

Workload
180 hours

T 5.46 Module component: Multivariable Control Systems [T-ETIT-114727]

Coordinators: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-107515 - Multivariable Control Systems

Type	Credits	Grading	Version
Written examination	6 CP	graded	1

Courses					
WT 26/27	2303193	Multivariable Control Systems	3 SWS	Lecture / 🗣	Kluwe
WT 26/27	2303194	Tutorial to 2303194 "Multivariable Control Systems"	1 SWS	Practice / 🗣	Fehn

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The examination takes place in form of a written examination lasting 120 minutes.

The module grade is the grade of the written exam.

Prerequisites
none

T 5.47 Module component: Nonlinear Continuum Mechanics [T-MACH-111026]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation:
Part of: M-MACH-107110 - Nonlinear Continuum Mechanics

Type	Credits	Grading	Term offered	Version
Oral examination	6 CP	graded	Each summer term	2

Courses					
ST 2026	2162344	Nonlinear Continuum Mechanics	2 SWS	Lecture / 🗣	Böhlke

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Assessment
oral examination (approx. 25 min)

Prerequisites
Passing the "Tutorial Nonlinear Continuum Mechanics" (T-MACH-111027) is a prerequisite for taking part in the exam.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module component T-MACH-111027 - Tutorial Nonlinear Continuum Mechanics must have been passed.

Recommendations
If you intend to take the course "Computational Elasticity" (T-MACH-113989) or "Computational Inelasticity" (T-MACH-113989), it is recommend to first take the course "Nonlinear Continuum Mechanics" (T-MACH-111026)

Additional Information
The corresponding course is offered in English.

Workload
180 hours

T 5.48 Module component: Nonlinear Control Systems [T-ETIT-114989]

Coordinators: Dr.-Ing. Mathias Kluwe
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-107644 - Nonlinear Control Systems

Type	Credits	Grading	Term offered	Version
Written examination	6 CP	graded	Each summer term	1

Courses					
ST 2026	2303320	Nonlinear Control Systems	3 SWS	Lecture / 🗣	Kluwe
ST 2026	2303321	Exercises to 2303320 Nonlinear Control Systems	1 SWS	Practice / 🗣	Handwerker

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

T 5.49 Module component: Nonlinear Process Control [T-CIWVT-112824]

Coordinators: Prof. Dr.-Ing. Thomas Meurer
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106316 - Nonlinear Process Control

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Courses					
WT 26/27	2243050	Nonlinear Process Control	3 SWS	Lecture / Practice / 🗣	Meurer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None.

T 5.50 Module component: Numerical Fluid Mechanics [T-BGU-106758]

Coordinators: Prof. Dr.-Ing. Markus Uhlmann
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-103375 - Numerical Fluid Mechanics

Type	Credits	Grading	Term offered	Expansion	Version
Written examination	6 CP	graded	Each term	1 semesters	2

Courses					
WT 26/27	6221702	Numerical Fluid Mechanics I	4 SWS	Lecture / Practice / 🗣	Uhlmann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
written exam, 90 min.

Prerequisites
none

Recommendations
none

Additional Information
none

Workload
180 hours

T 5.51 Module component: Numerical Fluid Mechanics II [T-BGU-106768]

Coordinators: Prof. Dr.-Ing. Markus Uhlmann
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-103384 - Advanced Computational Fluid Dynamics

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	3 CP	graded	Each term	1 semesters	2

Courses					
ST 2026	6221809	Numerical Fluid Mechanics II	2 SWS	Lecture / Practice / 🗣	Uhlmann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
oral exam, appr. 30 min.

Prerequisites
module 'Numerical Fluid Mechanics' must be completed

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-BGU-103375 - Numerical Fluid Mechanics must have been passed.

Recommendations
none

Additional Information
none

Workload
90 hours

T 5.52 Module component: Numerical Methods for Engineering Applications [T-MACH-115242]

Coordinators: Prof. Dr.-Ing. Luise Kärger
Organisation: KIT Department of Mechanical Engineering
Part of: M-MACH-107851 - Numerical Methods for Engineering Applications

Type	Credits	Grading	Term offered	Expansion	Version
Written examination	4 CP	graded	Each summer term	1 semesters	1

Assessment
written examination, 90 min

Prerequisites
T-MACH-113699 must not be started.

Additional Information
The course is offered in English.

The course in English will be offered for the first time in the summer semester of 2027. Registration for the exam with the English title will also not be possible until the summer semester of 2027. However, the exam is written in both German and English. English-speaking students who wish to take the exam earlier may therefore register for the exam with the German title.

Workload
120 hours

T 5.53 Module component: Numerical Simulation of Reacting Multiphase Flows [T-CIWVT-114118]

Coordinators: Prof. Dr. Oliver Thomas Stein
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-107076 - Numerical Simulation of Reacting Multiphase Flows

Type	Credits	Grading	Version
Oral examination	3 CP	graded	1

Courses					
ST 2026	2232120	Numerical Simulation of Reacting Multiphase Flows	2 SWS	Lecture / 🗣	Stein
ST 2026	2232121	Numerical Simulation of Reacting Multiphase Flows - Exercises	2 SWS	Practice / 🗣	Stein, und Mitarbeitende

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The learning control ist an oral examination lasting approx. 30 minutes.

Prerequisites
The prerequisite must be passed before taking the oral examination.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module component T-CIWVT-114117 - Numerical Simulation of Reacting Multiphase Flows - Prerequisite must have been passed.

T 5.54 Module component: Numerical Simulation of Reacting Multiphase Flows - Prerequisite [T-CIWVT-114117]

Coordinators: Prof. Dr. Oliver Thomas Stein
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-107076 - Numerical Simulation of Reacting Multiphase Flows

Type	Credits	Grading	Version
Coursework	5 CP	pass/fail	1

Courses					
ST 2026	**2232120**	Numerical Simulation of Reacting Multiphase Flows	**2 SWS**	**Lecture /**	**Stein**
ST 2026	**2232121**	Numerical Simulation of Reacting Multiphase Flows - Exercises	**2 SWS**	**Practice /**	**Stein, und Mitarbeitende**

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

Assessment
The learning control is a completed coursework: Reports on the tutorials documenting the processed task, the data generated and their analysis.

Prerequisites
None

T 5.55 Module component: Optimal and Model Predictive Control [T-CIWVT-112825]

Coordinators: Prof. Dr.-Ing. Thomas Meurer
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106317 - Optimal and Model Predictive Control

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Courses					
ST 2026	**2243030**	Optimal and Model Predictive Control	**2 SWS**	**Lecture / 🗣**	**Meurer**
ST 2026	**2243031**	Optimal and Model Predictive Control - Exercises	**1 SWS**	**Practice / 🗣**	**Meurer**

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.56 Module component: Optimal Control [T-ETIT-114701]

Coordinators: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-107497 - Optimal Control

Type	Credits	Grading	Term offered	Version
Written examination	6 CP	graded	Each winter term	1

Courses					
WT 26/27	2303183	Optimal Control	2 SWS	Lecture /	Hohmann
WT 26/27	2303185	Tutorial to 2303183 Optimal Control	2 SWS	Practice /	Riffel
WT 26/27	2303851	Accompanying Group Tutorial to 2303183 Optimal Control	1 SWS	Tutorial /	Riffel

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Assessment
The assessment consists of a written exam (120 min) taking place in the recess period.

Prerequisites
none

T 5.57 Module component: Parallel Computing [T-MATH-102271]

Coordinators: PD Dr. Mathias Krause
Prof. Dr. Christian Wieners
Organisation: KIT Department of Mathematics
Part of: M-MATH-101338 - Parallel Computing

Type	Credits	Grading	Term offered	Version
Oral examination	6 CP	graded	Irregular	2

Assessment
oral exam lasting approximately 20 minutes.

Workload
180 hours

T 5.58 Module component: Parallel Programming Techniques for Engineering [T-BGU-106769]

Coordinators: Prof. Dr.-Ing. Markus Uhlmann
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-103384 - Advanced Computational Fluid Dynamics

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	3 CP	graded	Each term	1 semesters	3

Courses					
ST 2026	6221807	Parallel Programming Techniques for Engineering Problems	2 SWS	Lecture / Practice / 🗣	Uhlmann

Legend: 🖥 Online, ✧ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
oral exam, appr. 30 min.

Prerequisites
module 'Numerical Fluid Mechanics' must be completed

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-BGU-103375 - Numerical Fluid Mechanics must have been passed.

Recommendations
none

Additional Information
none

Workload
90 hours

T 5.59 Module component: Particle Dynamics and Atomistic Simulation [T-MACH-114129]

Coordinators: Prof. Dr. Peter Gumbsch
Dr.-Ing. Johannes Schneider
Dr. Daniel Weygand

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107731 - Particle Dynamics and Atomistic Simulation

Type	Credits	Grading	Term offered	Version
Oral examination	4 CP	graded	Each summer term	2

Courses					
ST 2026	**2181740**	Particle Dynamics and Atomistic Simulation	**3 SWS**	**Lecture / Practice /** 🗣	**Weygand, Gumbsch**

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Oral exam: approximately 30 minutes

Prerequisites
none

Recommendations
Recommended prerequisites: Mathematics, Physics, and Materials Science

Additional Information
The course is offered in English.

Workload
120 hours

T 5.60 Module component: Phase-Field Method in Thermomechanics [T-MACH-114540]

Coordinators: Dr.-Ing. Andreas Prahs
Organisation: KIT Department of Mechanical Engineering
Part of: M-MACH-107459 - Phase-Field Method in Thermomechanics

Type	Credits	Grading	Term offered	Version
Oral examination	4 CP	graded	Each summer term	1

Assessment
Oral examination, duration approximately 30 minutes

Prerequisites
none

Additional Information
The course is offered in English.

Workload
120 hours

T 5.61 Module component: Polymer Thermodynamics [T-CIWVT-113796]

Coordinators: Prof. Dr. Sabine Enders
Prof. Dr.-Ing. Tim Zeiner
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-107781 - Polymer Thermodynamics

Type	Credits	Grading	Term offered	Version
Oral examination	6 CP	graded	Each winter term	2

Courses					
WT 26/27	2250060	Polymer Thermodynamics	2 SWS	Lecture / 🗣	Enders
WT 26/27	2250061	Exercises on 2250060 Polymer Thermodynamics	1 SWS	Practice / 🗣	Enders

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Learning control is an oral examination, duration about 30 minutes.

Prerequisites
None

T 5.62 Module component: Principles of Constrained Static Optimization [T-CIWVT-112811]

Coordinators: Dr.-Ing. Pascal Jerono
Prof. Dr.-Ing. Thomas Meurer

Organisation: KIT Department of Chemical and Process Engineering

Part of: M-CIWVT-106313 - Principles of Constrained Static Optimization

Type	Credits	Grading	Version
Oral examination	4 CP	graded	1

Courses					
WT 26/27	2243060	Principles of Constrained Static Optimization	2 SWS	Lecture / Practice / 🗣	Meurer, Jerono

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 5.63 Module component: Probabilistic Measurement and Estimation [T-MACH-114943]

Coordinators: Prof. Dr.-Ing. Christoph Stiller
Organisation: KIT Department of Mechanical Engineering
Part of: M-MACH-107613 - Probabilistic Measurement and Estimation

Type	Credits	Grading	Term offered	Version
Written examination	6 CP	graded	Each summer term	1

Courses					
ST 2026	2138334	Probabilistic Measurement and Estimation	3 SWS	Lecture / 🗣	Stiller, Steiner
ST 2026	2138338	Probabilistic Measurement and Estimation (Tutorial)	1 SWS	Practice / 🗣	Stiller, Steiner

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Assessment
written exam

60 min.

2 DIN A4 Self-created formular sheets allowed

Prerequisites
none

Additional Information
The course is offered in English

Workload
180 hours

T 5.64 Module component: Project [T-MACH-115051]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Chemical and Process Engineering
KIT Department of Mechanical Engineering
Part of: M-MACH-106948 - Project

Type	Credits	Grading	Expansion	Version
Examination of another type	6 CP	graded	1 semesters	1

Assessment
Learning control is an examination of another type. Term paper (max 30 pages) and presentation (duration approx. 20 minutes).

Prerequisites
None.

Additional Information
The course is offered in English.

Workload
180 hours

T 5.65 Module component: Quality Management [T-MACH-115056]

Coordinators: Prof. Dr.-Ing. Gisela Lanza
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-106946 - Economics and Law

Type	Credits	Grading	Term offered	Version
Written examination	4 CP	graded	Each winter term	2

Courses					
WT 26/27	2149667	Quality Management	2 SWS	Lecture / 🗣	Lanza

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Written Exam (60 min)

Prerequisites
It is not possible to combine this module component with module component Quality Management [T-MACH-112586].

Additional Information
The course is offered in English.

Workload
120 hours

T 5.66 Module component: Reactor Modeling with CFD [T-CIWVT-113224]

Coordinators: Prof. Dr.-Ing. Gregor Wehinger
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106537 - Reactor Modeling with CFD

Type	Credits	Grading	Version
Examination of another type	6 CP	graded	2

Courses					
ST 2026	2220060	Reactor Modeling with CFD	1 SWS	Lecture / 🗣	Wehinger, Schulz
ST 2026	2220061	Exercise Reactor Modeling with CFD	2 SWS	Practice / 🗣	Wehinger, und Mitarbeitende, Schulz

Legend: 🖥 Online, ✻ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None.

T 5.67 Module component: Robotics, Automation, and Systems Control Lab [T-ETIT-114740]

Coordinators: Prof. Dr.-Ing. Mike Barth
Prof. Dr.-Ing. Sören Hohmann

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-107524 - Robotics, Automation, and Systems Control Lab

Type	Credits	Grading	Term offered	Version
Examination of another type	6 CP	graded	Each summer term	2

Courses					
ST 2026	**2303195**	Robotics, Automation, and Systems Control Lab	**4 SWS**	**Practical course / 🗣**	**Breisacher, Wagemann, Witucki**

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The examination takes place in the form of other types of examination. It consists of pitches after every thematic block, a final presentation and an oral examination in the amount of 20 minutes. The overall impression is evaluated.

The module grade results of the assessment of the pitches, presentation and the oral exam. Details will be given during the lecture at the beginning of the semester.

Prerequisites
none

Recommendations
Knowledge in automation, control and robotics in general. Recommended, but not mandatory, lectures are:

- Practical Tools for Control Engineers, PTCE – M-ETIT-106780
- Cyber Physical Modeling – M-ETIT-106953
- Seminar Industrial Process and Plant Engineering – M-ETIT-106970
- Optimal Control – M-ETIT-107497
- Multivariable Control Systems – M-ETIT-107515
- Nonlinear Control Systems - in preparation

Additional Information
Due to capacity reasons there are only 25 places available. If necessary, a selection procedure will be carried out. Selection criteria are the progress in studies and in the recommended lectures. The application window is from March 1 for March 31 in Campus Plus (https://plus.campus.kit.edu/). For further information and current news, regularly visit the courses website (https://www.irs.kit.edu/Lectures_5404.php).

T 5.68 Module component: Scientific Literacy. Between “Follow the Science” and “Do Your Own Research” A Basic Seminar on the Relation Between Science and Society [T-FORUM-113972]

Organisation: General Studies. Forum Science and Society (FORUM)
Part of: M-MACH-106944 - Technology and Society

Type	Credits	Grading	Version
Coursework	2 CP	pass/fail	4

Courses					
ST 2026	**1130613**	Scientific Literacy. What Do People Do with Science? What Does Science Do with People? A basic Seminar on the Relation between Science and Society	**2 SWS**	**Seminar / 🗣**	**Roessing**
WT 26/27	**1100003**	Scientific Literacy. Between “follow the science” and “do your own research” A basic Seminar on the Relation between Science and Society	**2 SWS**	**Seminar / 🗣**	**Teutsch**

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Coursework that must include a presentation (maximum 30 minutes)

Prerequisites
none

Workload
60 hours

T 5.69 Module component: Self-Booking-MSc-HOC-SPZ-FORUM-Graded [T-MACH-113322]

Coordinators: Prof. Dr. Astrid Pundt
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-106945 - Key Competencies

Type	Credits	Grading	Term offered	Version
Examination of another type	1 CP	graded	Each term	1

Assessment
Completed coursework

Prerequisites
None

Self Service Assignment of Supplementary Studies
This module component can be used for self service assignment of grades acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)

Additional Information
Interdisciplinary qualifications (IQ) completed at the House-of-Competence (HoC), at the Forum Wissenschaft und Gesellschaft (FORUM, formerly ZAK) or at the Sprachenzentrum (SpZ) can be assigned in self-service.

First, select a partial accomplishment named "self-assignment" in your study schedule and second, assign an IQ-achievement via the tab "IQ achievements".

Workload
60 hours

T 5.70 Module component: Self-Booking-MSc-HOC-SPZ-FORUM-Graded [T-MACH-111687]

Coordinators: Prof. Dr.-Ing. Bettina Frohnapfel
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-106945 - Key Competencies

Type	Credits	Grading	Term offered	Version
Examination of another type	2 CP	graded	Each term	1

Assessment
Completed coursework

Prerequisites
None

Self Service Assignment of Supplementary Studies
This module component can be used for self service assignment of grades acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)

Additional Information
Interdisciplinary qualifications (IQ) completed at the House-of-Competence (HoC), at the FORUM (formerly ZAK) or at the Sprachenzentrum (SpZ) can be assigned in self-service.

First, select a partial accomplishment named "self-assignment" in your study schedule and second, assign an IQ-achievement via the tab "IQ achievements".

Workload
60 hours

T 5.71 Module component: Self-Booking-MSc-HOC-SPZ-FORUM-Non-Graded [T-MACH-113323]

Coordinators: Prof. Dr. Astrid Pundt
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-106945 - Key Competencies

Type	Credits	Grading	Term offered	Version
Coursework	1 CP	pass/fail	Each term	1

Assessment
Completed coursework

Prerequisites
None

Self Service Assignment of Supplementary Studies
This module component can be used for self service assignment of grades acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)

Additional Information
Interdisciplinary qualifications (IQ) completed at the House-of-Competence (HoC), at the Zentrum für Angewandte Kulturwissenschaften (ZAK) or at the Sprachenzentrum (SpZ) can be assigned in self-service.

First, select a partial accomplishment named "self-assignment" in your study schedule and second, assign an IQ-achievement via the tab "IQ achievements".

Workload
60 hours

T 5.72 Module component: Self-Booking-MSc-HOC-SPZ-FORUM-Non-Graded [T-MACH-111686]

Coordinators: Prof. Dr.-Ing. Bettina Frohnapfel
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-106945 - Key Competencies

Type	Credits	Grading	Term offered	Version
Coursework	2 CP	pass/fail	Each term	1

Assessment
Completed coursework

Prerequisites
None

Self Service Assignment of Supplementary Studies
This module component can be used for self service assignment of grades acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)

Additional Information
Interdisciplinary qualifications (IQ) completed at the House-of-Competence (HoC), at the FORUM (formerly ZAK) or at the Sprachenzentrum (SpZ) can be assigned in self-service.

First, select a partial accomplishment named "self-assignment" in your study schedule and second, assign an IQ-achievement via the tab "IQ achievements".

Workload
60 hours

T 5.73 Module component: Simulation of Fluid Separation Processes [T-CIWVT-113924]

Coordinators: Prof. Dr.-Ing. Tim Zeiner
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-106965 - Simulation of Fluid Separation Processes

Type	Credits	Grading	Version
Examination of another type	6 CP	graded	1

T 5.74 Module component: Statistical Thermodynamics [T-CIWVT-106098]

Coordinators: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-107779 - Statistical Thermodynamics

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Courses					
ST 2026	2250040	Statistical Thermodynamics	2 SWS	Lecture / 🗣	Enders
ST 2026	2250041	Statistical Thermodynamics - Exercises	1 SWS	Practice / 🗣	Enders

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
None

T 5.75 Module component: Technology Assessment and its Normative Basis [T-MACH-113884]

Coordinators: Prof. Dr. Dr. Rafaela Hillerbrand
Organisation: KIT Department of Mechanical Engineering
Part of: M-MACH-106944 - Technology and Society

Type	Credits	Grading	Term offered	Expansion	Version
Coursework	2 CP	pass/fail	Each winter term	1 semesters	3

Courses					
WT 26/27	5000057	Verantwortliche Technikgestaltung (=Theoriekurs)	2 SWS	Block	Hillerbrand

Assessment
Coursework in the form of written assignments and/or oral performances.

Prerequisites
none

Workload
60 hours

T 5.76 Module component: Theory of Stability [T-MACH-105372]

Coordinators: Prof. Dr.-Ing. Alexander Fidlin
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107108 - Theory of Stability

Type	Credits	Grading	Term offered	Version
Oral examination	6 CP	graded	Each summer term	1

Courses					
ST 2026	2163113	Theory of Stability	2 SWS	Lecture / 🗣	Fidlin
ST 2026	2163114	Theory of Stability (Tutorial)	2 SWS	Practice / 🗣	Fidlin, Luo

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
oral exam, approx. 30 min.

Prerequisites
none

Recommendations
Vibration theory, Mathematical Methods of Vibration Theory

Additional Information
The course will be offered in English from the summer semester 2027.

Workload
180 hours

T 5.77 Module component: Thermal Process Engineering II [T-CIWVT-114107]

Coordinators: Prof. Dr.-Ing. Tim Zeiner
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-107039 - Thermal Process Engineering II

Type	Credits	Grading	Version
Written examination	6 CP	graded	1

Courses					
ST 2026	2260150	Thermal Process Engineering II	2 SWS	Lecture / 🗣	Zeiner
ST 2026	2260151	Exercises on 2260150 Thermal Process Engineering II	2 SWS	Practice / 🗣	Zeiner, und Mitarbeitende

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None.

T 5.78 Module component: Thermodynamics of Interfaces [T-CIWVT-106100]

Coordinators: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-107780 - Thermodynamics of Interfaces

Type	Credits	Grading	Term offered	Version
Oral examination	6 CP	graded	Each summer term	3

Courses					
ST 2026	2250050	Thermodynamics of Interfaces	2 SWS	Lecture / 🗣	Enders
ST 2026	2250051	Exercises on 2250050 Thermodynamics of Interfaces	1 SWS	Practice / 🗣	Enders

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Erfolgskontrolle ist eine mündliche Prüfung im Umfang von 30 Minuten.

T 5.79 Module component: Tutorial Computational Elasticity [T-MACH-114529]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Dr.-Ing. Tom-Alexander Langhoff

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-107094 - Computational Elasticity

Type	Credits	Grading	Term offered	Version
Coursework	1 CP	pass/fail	Each winter term	1

Courses					
WT 26/27	2161147	Tutorial Computational Elasticity	2 SWS	Practice / 🗣	Hille, Speichinger, Langhoff

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Successful solution of the homework sheets. Details are announced during the first lecture "Computational Elasticity".

Recommendations
see course "Computational Elasticity"

Additional Information
The corresponding course is offered in English. Further Information can be found in the course description "Computational Elasticity"

Workload
30 hours

T 5.80 Module component: Tutorial Computational Inelasticity [T-MACH-114530]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Dr.-Ing. Tom-Alexander Langhoff
Organisation: KIT Department of Mechanical Engineering
Part of: M-MACH-107095 - Computational Inelasticity

Type	Credits	Grading	Term offered	Version
Coursework	1 CP	pass/fail	Each summer term	1

Courses					
ST 2026	2162297	Tutorial Computational Inelasticity	2 SWS	Practice / 🗣	Gisy, Speichinger, Böhlke, Langhoff

Legend: 🖥 Online, ❋ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Successful solution of the homework sheets. Details are announced during the first lecture "Computational Inelasticity".

Recommendations
see course "Computational Inlasticity"

Additional Information
The corresponding course is offered in English. Further Information can be found in the course description "Computational Inelasticity"

Workload
30 hours

T 5.81 Module component: Tutorial Computational Mechanics of Materials [T-MACH-113940]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-106947 - Mechanics

Type	Credits	Grading	Term offered	Version
Coursework	2 CP	pass/fail	Each winter term	1

Courses					
WT 26/27	**2161255**	Tutorial Computational Mechanics of Materials	**2 SWS**	**Practice / 🗣**	**Hille, Lalović, Böhlke**

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Presentation of project results. Subsequent discussion within the course.

Prerequisites
None

Additional Information
The corresponding course is offered in English. Further Information can be found in the course description 2161259 "Computational Mechanics of Materials"

Workload
60 hours

T 5.82 Module component: Tutorial Nonlinear Continuum Mechanics [T-MACH-111027]

Coordinators: Prof. Dr.-Ing. Thomas Böhlke
Organisation:
Part of: M-MACH-107110 - Nonlinear Continuum Mechanics

Type	Credits	Grading	Term offered	Expansion	Version
Coursework	2 CP	pass/fail	Each summer term	1 semesters	2

Courses					
ST 2026	2162345	Tutorial in Nonlinear Continuum Mechanics	2 SWS	Practice / 🗣	Hille, Klein, Böhlke

Legend: 🖥 Online, ⚭ Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Assessment
Successful solution of worksheets. Details are given in the first lecture

Successful participation in this course allows for registration to the Exam "Nonlinear Continuum Mechanics" (see 76-T-MACH-111026)

Prerequisites
none

Additional Information
The corresponding course is offered in English. Further Information can be found in the course description 2162345 "Tutorial in Nonlinear Continuum Mechanics"

Workload
60 hours

T 5.83 Module component: Wave Propagation in Solids [T-BGU-115337]

Coordinators: Prof. Dr.-Ing. Thomas Seelig
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-107916 - Wave Propagation in Solids

Type	Credits	Grading	Term offered	Expansion	Version
Oral examination	3 CP	graded	Each term	1 semesters	1

Assessment
oral exam, appr. 30 min.

Prerequisites
none

Recommendations
basic knowledge of continuum mechanics and partial differential equations

Additional Information
The course 'Wave Propagation in Solids' will be offered for the first time in the summer term 2027.

Workload
90 hours

6 Appendix

6.1 Definition

- CR - Credit(s)
- MTh - Master's Thesis
- OE - Oral examination
- WE - Written examination
- Eoat -Examination of another type
- CW -Coursework (ungraded)
- Wght -Weighting of an examination performance in the module or in the overall grade
- SER - Study and examination regulations (German SPO)
- ECTS - European Credit Transfer and Accumulation System