Karlsruhe Institute of Technology

Module Handbook
MSc, Mechanical Engineering (M.Sc.)

Valid from Winter Term 2018/2019
Long version (SPO from 06.08.2015)
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Faculty of Mechanical Engineering

KIT - University of the State of Baden-Wuerttemberg and
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Studienplan der KIT-Fakultät für Maschinenbau für den Masterstudiengang Maschinenbau gemäß SPO 2015

Fassung vom18. Juni 2018

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Vertiefungsrichtungen:	MB	Allgemeiner Maschinenbau
	E+U	Energie- und Umwelttechnik
	FzgT	Fahrzeugtechnik
	M+M	Mechatronik und Mikrosystemtechnik
	PEK	Produktentwicklung und Konstruktion
	PT	Produktionstechnik
	ThM	Theoretischer Maschinenbau
	W+S	Werkstoffe und Strukturen für Hochleistungssysteme
Semester:	WS	Wintersemester
	SS	Sommersemester
Schwerpunkte:	K, KP	Teilleistung im Kernbereich, ggf. Pflicht des Schwerpunkts
	E	Teilleistung im Ergänzungsbereich des Schwerpunkts
	EM	Teilleistung im Ergänzungsbereich ist nur im Masterstudiengang wählbar
Lehrveranstaltung:	V	Vorlesung
	Ü	Übung
	P	Praktikum
	SWS	Semesterwochenstunden
Teilleistung:	LP	Leistungspunkte
	Pr	Prüfung
	mPr	mündliche Prüfung
	sPr	schriftliche Prüfung
	PraA	Prüfungsleistung anderer Art
	Schein	unbenotete Modulleistung
	TL	Teilleistung
	Gew	Gewichtung einer Prüfungsleistung im Modul bzw. in der Gesamtnote
Sonstiges:	SPO	Studien- und Prüfungsordnung
	w	wählbar
	p	verpflichtend

1 Studienpläne, Module und Prüfungen

Das Masterstudium kann sowohl zum Winter- als auch zum Sommersemester aufgenommen werden. Wegen der freien Wahl der Module lässt sich für das Masterstudium kein exemplarischer Studienverlauf angeben.

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

1.1 Prüfungsmodalitäten

In jedem Semester wird für Prüfungen mindestens ein Prüfungstermin angeboten. Prüfungstermine sowie Termine, zu denen die Anmeldung zu den Prüfungen spätestens erfolgen muss, werden vom Prüfungsausschuss festgelegt. Die Anmeldung für die Prüfungen erfolgt in der Regel mindestens eine Woche vor der Prüfung. Anmelde- und Prüfungstermine werden rechtzeitig durch Anschlag bekanntgegeben, bei schriftlichen Prüfungen mindestens 6 Wochen vor der Prüfung.

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

Studienleistungen/Scheine können solange beliebig oft wiederholt werden, bis diese erfolgreich absolviert wurden.

1.2 Vertiefungsrichtungen

Es stehen folgende Vertiefungsrichtungen zur Auswahl:

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

Die Wahlmöglichkeiten im Wahlpflichtmodul „Grundlagen und Methoden der Vertiefungsrichtung“ und in den Schwerpunkten richten sich nach der gewählten Vertiefungsrichtung. Die zur Verfügung stehenden Module der Vertiefungsrichtungen werden im Modulhandbuch aufgeführt. Schriftliche Prüfungen werden als Klausuren mit der angegebenen Prüfungsdauer in Stunden abgenommen. Prüfungsleistungen gehen mit dem angegebenen Gewicht (Gew) in die Gesamtnote ein.

Folgende Module sind im Masterstudiengang zu belegen:

Fach	Modul	LP/ Modul	Teilleistung	LP/ TL	Koordinator	Art der Erfolgskontrolle	Pr (h)	Gew
Vertiefung ingenieurwissenschaftlicher Grundlagen	Produktentstehung – Bauteildimensionierung	7	Produktentstehung - Bauteildimensionierung	7	Schulze	sPr	2	7
	Produktentstehung - Entwicklungsmethodik	6	–Methoden und Prozesse der PGE - Produtgenerationsentwicklung	6	Matthiesen, Albers	sPr	2	6
	Modellbildung und Simulation	7	Modellbildung und Simulation	7	Proppe	sPr	3	7
	Mathematische Methoden	6	wählbare TL s. Modulhandbuch	6	Heilmaier	sPr	3[1]	6
	Laborpraktikum	4	wählbare TL s. Modulhandbuch	4	Stiller, Furmans	Schein		
	Wahlpflichtmodul Maschinenbau	8	Teilleistung 1, wählbare TL s. Modulhandbuch	4	Heilmaier	mPr	ca. 0:20	4
			Teilleistung 2, wählbare TL s. Modulhandbuch	4	Heilmaier	mPr	ca. 0:20	4
	Wahlpflichtmodul nat/inf/etit	6	wählbare TL s. Modulhandbuch	6	Maas	Schein		
	Wahlpflichtmodul wirt/recht	4	wählbare TL s. Modulhandbuch	4	Furmans	Schein		
	Schlüsselqualifikationen	2	wählbare TL von HoC, ZAK bzw. Modulhandbuch	2		Schein		
Vertiefungsrichtung	Schwerpunkt 1	16	Kernbereich, wählbare TL s. Modulhandbuch	8	SP-Verantwortlicher	mPr	ca. 0:40	8
			Ergänzungsbereich, wählbare TL s. Modulhandbuch	8		2x mPr	ca. 2x 0:20	8
	Schwerpunkt 2	16	Kernbereich, wählbare TL s. Modulhandbuch	8	SP-Verantwortlicher	mPr	ca. 0:40	8
			Ergänzungsbereich, wählbare TL s. Modulhandbuch	8		2xmPr	ca. 2x 0:20	8
	Grundlagen und Methoden der Vertiefungsrichtung	8	Teilleistung 1, wählbare TL s. Modulhandbuch	4	Heilmaier	mPr, sPr	ca. 0:20 bzw. 1:30 - 3:00	4
			Teilleistung 2, wählbare TL s. Modulhandbuch	4	Heilmaier	mPr, sPr	ca. 0:20 bzw. 1:30 - 3:00	4
Masterarbeit	Masterarbeit	30	Masterarbeit und Präsentation	30		PraA		30

[1] Bei der Veranstaltung „Wahrscheinlichkeitstheorie und Statistik“ beträgt die Prüfungsdauer abweichend 1,5 h.

2 Zugelassene Teilleistungen in den Wahlpflichtmodulen

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

2.1 Wahlpflichtmodul Grundlagen und Methoden der Vertiefungsrichtung

Im Masterstudiengang müssen zwei Teilleistungen mit jeweils 4 LP im Modul Grundlagen und Methoden der jeweiligen Vertiefungsrichtung erbracht werden.

Sofern in der Vertiefungsrichtung Teilleistungen in der unten stehenden Tabelle mit „p“ gekennzeichneten sind, muss eine dieser Teilleistungen erbracht werden, die andere Teilleistung muss aus dem mit „w“ gekennzeichneten Angebot erbracht werden. In einem konsekutiven Masterstudium kann eine solche p-Teilleistung durch eine w-Teilleistung ersetzt werden, wenn die entsprechende p-Teilleistung bereits im Bachelorstudium belegt wurde. Für manche Schwerpunkte wird eine spezielle Teilleistung empfohlen (siehe Hinweis beim jeweiligen Schwerpunkt im aktuellen Modulhandbuch). Ist in einer Vertiefungsrichtung keine Teilleistung mit „p“ gekennzeichnet, kann aus den w-Teilleistungen vollumfänglich gewählt werden.

Folgende Teilleistungen sind derzeit vom Fakultätsrat für die Vertiefungsrichtungen des Masterstudiengangs genehmigt:

Nr.	Teilleistung	MB	E+U	FzgT	M+M	PEK	PT	ThM	W+S
(1)	Arbeitswissenschaft I, Ergonomie	w				w	w		
(2)	CAE-Workshop	w	w	w	w	w	w		w
(3)	Einführung in die Mechatronik	w	w	w	p	w	w		
(4)	Elektrotechnik II			w					
(5)	Fluidtechnik	w	w	w		w	w	w	
(6)	Wahrscheinlichkeitstheorie und Statistik			w	w			w	
(7)	Einführung in die Mehrkörperdynamik	w	w	w	w	w	w	w	w
(8)	Grundlagen der Mikrosystemtechnik I oder II[1]	w			w	w	w		
(9)	Grundlagen der technischen Logistik	w	w	w	w	w	w	w	w
(10)	Grundlagen der technischen Verbrennung I	w	w	w	w			w	
(11)	Maschinendynamik	w	w	w	w	w	w	w	w
(12)	Mathematische Methoden der Dynamik	w		w	w	w		w	
(13)	Mathematische Methoden der Festigkeitslehre	w		w	w	w	w	w	w
(14)	Mathematische Methoden der Schwingungslehre	w		w	w	w		w	
(15)	Mathematische Methoden der Strömungslehre	w	w	w		w		w	

[1] Es kann nur eine der beiden Teilleistungen erbracht werden.

Nr.	Teilleistung	MB	E+U	FzgT	M+M	PEK	PT	ThM	W+S
(16)	Mathematische Methoden der Strukturmechanik	w			w	w		w	w
(17)	Mathematische Modelle und Methoden für Produktionssys-teme	w					w	w	
(18)	Mikrostruktursimulation	w						w	w
(19)	Modellierung und Simulation	w					w	w	w
(20)	Moderne Physik für Ingenieure *oder* Physik für Ingenieure[1]	w	w	w	w			w	w
(21)	Neue Aktoren und Sensoren	w	w	w	w	w	w		
(22)	Numerische Mathematik für die Fachrichtungen Informatik und Ingenieurwesen		w	w	w		w	w	
(23)	Physikalische Grundlagen der Lasertechnik	w	w	w	w	w	w		w
(24)	Product Lifecycle Management	w		w	w	w	w		
(25)	Systematische Werkstoff-auswahl	w	w	w	w	w	w	w	p
(26)	Technische Grundlagen des Verbrennungsmotors	w	w	w	w	w			
(27)	Technische Informations-systeme	w		w	w	w	w		
(28)	Technische Schwingungslehre	w	w	w	w	w	w	w	w
(29)	Wärme- und Stoffübertragung	w	p	w	w	w		w	
(30)	Wissenschaftliches Program-mieren für Ingenieure	w						w	w

2.2 Mathematische Methoden

Wählbare Teilleistungen siehe Modulhandbuch.

2.3 Wahlpflichtmodul aus dem Bereich Naturwissenschaften/Informatik/Elektrotechnik

Wählbare Teilleistungen siehe Modulhandbuch. Der Wechsel der gewählten Teilleistung ist bis zum Bestehen der Erfolgskontrolle möglich. Andere Teilleistungen, auch aus anderen Fakultäten, können mit Genehmigung des Prüfungsausschusses gewählt werden.

2.4 Wahlpflichtmodul aus dem Bereich Wirtschaft/Recht

Wählbare Teilleistungen siehe Modulhandbuch. Der Wechsel der gewählten Teilleistung ist bis zum Bestehen der Erfolgskontrolle möglich. Andere Teilleistungen, auch aus anderen Fakultäten, können mit Genehmigung des Prüfungsausschusses gewählt werden.

[1] Es kann nur eine der beiden Teilleistungen erbracht werden.

2.5 Wahlpflichtmodul aus dem Bereich Maschinenbau

Wählbare Teilleistungen siehe Modulhandbuch. Andere Teilleistungen, auch aus anderen Fakultäten, können mit Genehmigung des Prüfungsausschusses gewählt werden.

2.6 Laborpraktikum

Wählbare Teilleistungen siehe Modulhandbuch. Der Wechsel der gewählten Teilleistung ist bis zum Bestehen der Erfolgskontrolle möglich.

3 Schwerpunkte

Generell gilt, dass jede Teilleistung und jeder Schwerpunkt nur einmal entweder im Rahmen des Bachelorstudienganges und des konsekutiven Masterstudiengangs Maschinenbau gewählt werden kann.

3.1 Zuordnung der Schwerpunkte zu den Vertiefungsrichtungen

Folgende Schwerpunkte sind derzeit vom Fakultätsrat genehmigt. In einigen Vertiefungsrichtungen ist die Wahl des **ersten** Schwerpunkts eingeschränkt (einer der mit „p“ gekennzeichneten Schwerpunkte ist zu wählen).
In einem konsekutiven Masterstudium kann der erste Masterschwerpunkt auch als w-Schwerpunkt gewählt werden, wenn ein p-Schwerpunkt dieser Vertiefungsrichtung bereits im Bachelorstudium gewählt wurde.

Schwerpunkt	SP-Verant-wortlicher	SP-Nr.	MB	E+U	FzgT	M+M	PEK	PT	ThM	W+S
Advanced Materials Modelling	Böhlke	56	w						w	w
Advanced Mechatronics	Mikut	1	w	w	w	p	w	w	w	
Angewandte Mechanik	Böhlke	30	w	w	w	w	w	w	p	w
Antriebssysteme	Albers	2	w		w		w	w		
Automatisierungstechnik	Mikut	4	w	w	w	p	w	w	w	
Bahnsystemtechnik	Gratzfeld	50	w		p	w	w			
Computational Mechanics	Proppe	6	w		w	w	w		p	
Entwicklung innovativer Geräte	Matthiesen	51	w	w	w		p	w		
Entwicklung und Konstruktion	Albers	10	w	w	w		w	w		
Fahrdynamik, Fahrzeugkomfort und -akustik	Gauterin	11	w		w	w	w		w	
Fusionstechnologie	Stieglitz	53	w	w					w	
Gebäudeenergietechnik	H.-M. Henning	55	w	w						
Grundlagen der Energietechnik	Bauer	15	w	p	w	w	w			
Informationstechnik	Stiller	18	w	w	w	w	w	w	w	
Informationstechnik für Logistiksysteme	Furmans	19	w				w	w		
Innovation und Entrepreneurship	Class	59		w						
Integrierte Produktentwicklung	Albers	20	w	w	w		p	w		
Kerntechnik	Cheng	21	w	w					w	
Kognitive Technische Systeme	Stiller	22	w		w	w	w	w	w	
Kraftfahrzeugtechnik	Gauterin	12	w		p		w			
Kraft- und Arbeitsmaschinen	Th. Koch	24	w	w	w		w			

Studienplan für den Masterstudiengang Maschinenbau gem. SPO 2015.
Gültig ab 01.10.2018, auf Beschlussfassung des Fakultätsrats vom 18.07.2018. Seite 7 von 10

Schwerpunkt	SP-Verant-wortlicher	SP-Nr.	MB	E+U	FzgT	M+M	PEK	PT	ThM	W+S
Kraftwerkstechnik	Bauer	23	w	w			w			
Leichtbau	F. Henning	25	w	w	w		w	w		w
Lifecycle Engineering	Ovtcha-rova	28	w		w	w	p	p		
Logistik und Materialflusslehre	Furmans	29	w				w	p		
Materialwissenschaft und Werkstofftechnik	Heilmaier	26	w	w	w	w	w	w	w	p
Mechatronik	Hagen-meyer	31	w	w	w	p	w	w	w	
Medizintechnik	Pylatiuk	32	w			w	w			
Mensch - Technik - Organisation	Deml	3	w	w			w	p		
Mikroaktoren und Mikrosenso-ren	Kohl	54	w	w	w	w	w	w		
Mikrosystemtechnik	Korvink	33	w	w	w	p	w	w		
Mobile Arbeitsmaschinen	Geimer	34	w		p	w	w	w		
Modellbildung und Simulation in der Dynamik	Seemann	61	w	w	w	w	w	w	p	
Modellierung und Simulation in der Energie- und Strömungs-technik	Maas	27	w	w	w	w	w			
Polymerengineering	Elsner	36	w	w	w		w	w		w
Produktionstechnik	Schulze	39	w		w		w	p		
Robotik	Mikut	40	w			p	w	w	w	
Schwingungslehre	Fidlin	60	w	w	w	w	w	w	p	
Strömungsmechanik	Frohnapfel	41	w	w	w		w		p	
Technische Keramik und Pulverwerkstoffe	Hoffmann	43	w	w	w		w			w
Technische Logistik	Furmans	44	w				w	w		
Technische Thermodynamik	Maas	45	w	w	w	w	w		w	w
Thermische Turbomaschinen	Bauer	46	w	w	w				w	w
Tribologie	Dienwiebel	47	w	w	w	w	w	w	w	w
Verbrennungsmotorische Antriebssysteme	Th. Koch	58	w	w	p	w	w			
Zuverlässigkeit im Maschinenbau	Gumbsch	49	w	w	w	w	w	w	w	p

Für jeden Schwerpunkt werden Teilleistungen im Umfang von 16 LP gewählt, davon werden mindestens 8 LP im Kernbereich (K) erworben. „KP“ bedeutet, dass die Lehrveranstaltung im Kernbereich Pflicht ist, sofern sie nicht bereits belegt wurde. Die übrigen 8 LP können aus dem Ergänzungsbereich kommen. Dabei dürfen im Rahmen von Praktika höchstens 4 LP erworben werden, die auch als Studienleistung erbracht werden können.

Die im Ergänzungsbereich (E) angegebenen Teilleistungen verstehen sich als Empfehlung, andere Teilleistungen (auch aus anderen KIT-Fakultäten) können mit Genehmigung des jeweiligen Schwerpunktverantwortlichen gewählt werden. Dabei ist eine Kombination mit Teilleistungen aus den Bereichen Informatik, Elektrotechnik und Mathematik in einigen Vertiefungsrichtungen besonders willkommen.

Ein Absolvieren des Schwerpunktmoduls mit mehr als 16 LP ist nur im Fall, dass die Addition innerhalb des Schwerpunktmoduls nicht auf 16 LP aufgeht, erlaubt. Nicht zulässig ist es jedoch, noch weitere Teilleistungen anzumelden, wenn bereits 16 LP erreicht oder überschritten wurden.

Für die Prüfungsleistungen in den Schwerpunkten gelten folgende Regeln:
Die Prüfungen werden grundsätzlich mündlich abgenommen, bei unvertretbar hohem Prüfungsaufwand kann eine mündlich durchzuführende Prüfung auch schriftlich abgenommen werden. Es wird empfohlen, die Kernbereichsprüfung im Block abzulegen. Bei mündlichen Prüfungen im Schwerpunkt soll die Prüfungsdauer fünf Minuten pro Leistungspunkt betragen. Erstreckt sich eine mündliche Prüfung über mehr als 12 LP, soll die Prüfungsdauer 60 Minuten betragen.

Die Bildung der Schwerpunktnote erfolgt anhand der mit einer Prüfungsleistung abgeschlossenen Teilleistungen. Dabei werden alle Teilleistungen gemäß ihrer Leistungspunkte gewichtet. Bei der Bildung der Gesamtnote wird der Schwerpunkt mit 16 LP gewertet.

Die Beschreibung der Schwerpunkte hinsichtlich der jeweils darin enthaltenen Teilleistungen und den damit verbundenen Lehrveranstaltungen ist im aktuellen Modulhandbuch des Masterstudiengangs festgelegt.

4 Masterarbeit

Für die Betreuung der Masterarbeit stehen je nach Vertiefungsrichtung folgende Institute (●) zur Wahl:

Institut für	**Abk.**	**MB**	**E+UT**	**FzgT**	**M+M**	**PEK**	**PT**	**ThM**	**W+S**
Automation und angewandte Informatik	IAI	●	●	●	●	●	●	●	●
Angewandte Werkstoffphysik	IAM-AWP	●	●	●	●	●	–	●	●
Arbeitswissenschaft und Betriebsorganisation	ifab	●	●	●	–	●	●	–	–
Fahrzeugsystemtechnik	FAST	●	●	●	●	●	–	●	●
Fördertechnik und Logistiksysteme	IFL	●	–	–	–	●	●	●	–
Informationsmanagement im Ingenieurwesen	IMI	●	–	●	●	●	●	–	–
Keramische Werkstoffe und Technologien	IAM-KWT	●	●	–	–	●	–	–	●
Fusionstechnologie und Reaktortechnik	IFRT	●	●	–	–	–	–	–	–
Kolbenmaschinen	IFKM	●	●	●	–	●	–	–	–
Mess- und Regelungstechnik	MRT	●	●	●	●	●	–	●	–
Mikrostrukturtechnik	IMT	●	●	●	●	●	●	–	–
Produktentwicklung	IPEK	●	●	●	●	●	●	–	●
Produktionstechnik	WBK	●	–	●	●	●	●	–	●
Strömungsmechanik	ISTM	●	●	●	●	●	–	●	–
Technische Mechanik	ITM	●	●	●	●	●	●	●	●

Institut für	Abk.	MB	E+UT	FzgT	M+M	PEK	PT	ThM	W+S
Thermische Strömungsmaschinen	IST	●	●	●	–	●	–	●	●
Technische Thermodynamik	ITT	●	●	●	–	–	–	●	–
Werkstoff- und Biomechanik	IAM-WBM	●	●	●	●	●	●	●	●
Werkstoffkunde	IAM-WK	●	●	●	●	●	●	●	●
Computational Materials Science	IAM-CMS	●	●	●	●	●	–	●	●
Kern- und Energietechnik	IKET	●	●	–	–	–	–	–	–

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

5 Änderungshistorie (ab 22.04.2015)

07.11.2016	redaktionelle Anpassung der TL-Namen in 2.1
28.06.2017	redaktionelle Anpassungen
13.07.2018	Anpassung der Schwerpunkte sowie redaktionelle Änderungen

2 Learning Outcomes

Learning Outcomes (M.Sc., Mechanical Engineering, KIT), 10/01/2018

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

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

In the specialization area, consisting of two major fields and associated electives, graduates acquire the essential knowledge, how to transfer the general fundamentals into concrete issues of mechanical engineering. Thus they are qualified to play an important role in complex research and development projects as well as to participate competently in the innovation process and are professionally prepared for future leadership roles.

In other natural sciences, economics and social sciences related electives, students acquire further skills. Thereby they are, inter alia, in a position to make well thought out decisions, taking into account social, economic and ethical constraints.

Graduates of the Master's program in mechanical engineering at KIT have broad and in-depth knowledge. This solid foundation enables them to analyze and synthesize complex systems. They can also develop, reflect, evaluate and shape independently and sustainably systems and processes of mechanical engineering, taking into account technical, social, economic and ethical constraints. They deal constructively with their own and with others' views and present their work results in an understandable form. Graduates are able to independently identify tasks, to obtain the information necessary to their solution, to select methods, to acquire skills and thus to contribute to added value. They are in a position to choose a concrete occupational area of mechanical engineering.

3 Modules

3.1 Compulsory Modules

Module: Product Development - Dimensioning of Components [MSc-Modul, PE-B (2016)]

Coordination: V. Schulze, S. Dietrich
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
7		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2150511	Product Development - Dimensioning of Components (p. 308)	3	S	7	V. Schulze, S. Dietrich

Learning Control / Examinations
The assessment is carried out as a written exam (2 hours).

Conditions
None

Recommendations
None

Learning Outcomes
The students. . .

- are capable to design and dimension components according to their load.
- can include mechanical material properties from the mechanical material test in the dimensioning process.
- can identify superimposed total loads and critical loads on simple components and to compute them.
- acquire the skill to select materials based on the application area of the components and respective loads.

Content
The aim of the lecture is to present the topics of the dimensioning and the material science in their connection and to learn how to deal with corresponding methods and the combination thereof.
For the prospective engineer the most important educational objective is to understand the interaction of these topics while the interplay of the individual material stresses in the component are clarified.

The topics in detail are

Structural dimensioning: basic stresses, superimposed stresses, notch influence, fatigue limit, fatigue strength, assessment of cracked components, operational strength, residual stresses, high temperature stress and corrosion

Material selection: Basics, material indices, material selection diagrams, Ashby procedure, multiple boundary conditions, target conflicts, shape and efficiency.

Module: Product Development - Methods of Product Development [MSc-Modul, PE-E (2016)]

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

ECTS Credits	Cycle	Duration
6		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2146280	Methods and Processes of PGE – Product Generation Engineering (p. 247)	3	S	6	A. Albers, N. Burkardt

Learning Control / Examinations
Written exam
Duration: 120 minutes
Auxiliaries:

- Calculator
- German dictionary (books only)

Conditions
None.

Learning Outcomes
The students are ...

- Classify product development in companies and differentiate between different types of product development.
- Identify the market factors relevant to product development.
- Explain the concept of innovation and the need for innovation for companies.
- Understand the description model of PGE product generation engineering and link it to relevant influences on customer satisfaction and cross-generational variations.
- Identify the strengths and weaknesses of people as problem solvers and explain how problem-solving methods support the developer.
- Identify and understand problems and use a problem-solving methodology when confronted with problems, know their process, the meaning of the individual steps and can apply them.
- Distinguish, describe and characterize different process models of product development.
- Understand the iPeM - integrated Product engineering Model, model development processes and apply the iPeM in various development situations.
- Identify and compare the central methods and process models of product development and apply them to the development of moderately complex technical systems.
- Explain problem-solving systems and assign corresponding development methods.
- Explain product profiles and, based on this, differentiate and select suitable creativity techniques for finding solutions / ideas.

- Understanding and applying agile processes.
- Explain the challenges of agile approaches and explain the different requirements and boundary conditions between agile software development and product generation development.
- Discuss design guidelines for the design of technical systems and apply them to the development of slightly complex technical systems.
- Identify, compare and select quality assurance methods for early product development phases and apply them to moderately complex technical systems.
- Explain methods of statistical design of experiments.
- Explain cost generation and cost responsibility in the design process.

Content
Basic principles of product development: basic concepts, classification of product development in the market environment, overview of sales markets, role of competition and customer role, product technology and industry life cycles, market risks

- Innovation and market success: innovation process, product profiles, invention and market launch
- System and Model Theory: Error of Thought in Problem Solving, General Model Theory according to Stachowiak, System Theory of Technology according to Ropohl, Methods of Modeling, Design Structure Matrix (DSM), System Modeling Language (SysML)
- PGE - Product Generation Engineering: Explanation Model of the PGE, the Kano Model
- The concept of the problem: definition of the problem, the human being as problem solver, problem solving techniques, iterations in problem solving
- Problem solving technique SPALTEN: Basics of the problem solving technique SPALTEN, detailed activity sequence of SPALTEN
- Process models: Application of process models, overview of established process models
- iPeM - integrated Product engineering Model: introduction to the system Tripel, basic activities in iPeM, product development activities in iPeM
- ASD - Agile Systems Design: Challenges in the agile development of mechatronic systems, the basic principles of ASD - Agile Systems Design, application of ASD - Agile Systems Design
- Design for X: Dfx and Standardization, Design for Quality, Design for Lightweight Construction

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

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

ECTS Credits	Cycle	Duration
7		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2185227	Modeling and Simulation (p. 256)	4	W	7	C. Proppe, K. Furmans, B. Pritz, M. Geimer

Learning Control / Examinations
written exam, 3 hours

Conditions
none

Recommendations
none

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

- They are able to formulate the steps necessary to resolve problems arising in engineering, to create appropriate conceptual and mathematical models and to analyze them.

- They are able to develop and implement algorithms for the solution of mathematical models.

- They are able to perform comprehensive and interdisciplinary simulation studies to assess the simulation results and to critically evaluate the quality of the simulation results.

Content
Introduction: Overview, concept formation, simulation studies, time/event-discrete models, event-oriented/process orientated/transaction-oriented view, typical model classes (operation/maintenance, storekeeping, loss-susceptible systems)
Time-continuous models with concentrated parameters, model characteristics and model analysis, numerical treatment of ordinary differential equations and differential-algebraic sets of equations, coupled simulation of time-continuous models with concentrated parameters
Time-continuous models with distributed parameters, description of systems by means of partial differential equations, model reduction, numerical solution procedures for partial differential equations

3.2 Compulsory Elective Modules

Module: Mathematical Methods [MSc-Modul 08, MM]

Coordination: M. Heilmaier
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
6		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2161206	Mathematical Methods in Dynamics (p. 229)	2	W	5	C. Proppe
2161254	Mathematical Methods in Strength of Materials (p. 230)	3	W	5	T. Böhlke
2162241	Mathematical methods of vibration theory (p. 232)	3	S	5	W. Seemann
2154432	Mathematical Methods in Fluid Mechanics (p. 233)	3	S	6	B. Frohnapfel, D. Gatti
2162280	Mathematical Methods in Structural Mechanics (p. 234)	3	S	5	T. Böhlke
2117059	Mathematical models and methods for Production Systems (p. 237)	4	W	6	K. Furmans, M. Rimmele
0187400	Numerical Mathematics (p. 275)	3	S	6	C. Wieners, D. Weiß, Neuß, Rieder
0186000	Probability Theory and Statistics (p. 392)	3	S	5	D. Hug

Learning Control / Examinations
graded written examination

Conditions
None.

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

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

Content
see chosen elective subject

Remarks
One of the lectures listed above has to be chosen.

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

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

ECTS Credits	Cycle	Duration
4		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2117084	Decentrally controlled intralogistic systems (p. 106)	2	W/S	4	K. Furmans, M. Hochstein, K. Markert
2175590	Metallographic Lab Class (p. 136)	3	W/S	4	U. Hauf
2115808	Motor Vehicle Laboratory (p. 207)	2	W/S	4	M. Frey
2143877	Introduction to Microsystem Technology - Practical Course (p. 209)	2	W/S	4	A. Last
2171487	Laboratory Exercise in Energy Technology (p. 214)	3	W/S	4	H. Bauer, U. Maas, H. Wirbser
2105014	Laboratory mechatronics (p. 242)	3	W	4	C. Stiller, M. Lorch, W. Seemann
2138328	Measurement Instrumentation Lab (p. 244)	2	S	4	C. Stiller, M. Spindler
2134001	Engine Laboratory (p. 262)	2	S	4	U. Wagner
2117070	Plug-and-play material handling (p. 293)	2	W	4	K. Furmans, J. Dziedzitz
2162275	Lab course experimental solid mechanics (p. 304)	2	S	4	T. Böhlke, Mitarbeiter
2171488	Workshop on computer-based flow measurement techniques (p. 303)	3	W/S	4	H. Bauer
2183640	Laboratory "Laser Materials Processing" (p. 302)	3	W/S	4	J. Schneider, W. Pfleging
2110678	Production Techniques Laboratory (p. 310)	3	S	4	K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL
2146210	ProVIL - Product development in a Virtual Idea Laboratory (p. 318)	3	S	4	A. Albers, -
2161241	Schwingungstechnisches Praktikum (p. 332)	3	S	4	A. Fidlin
2155425	Flow Measurement Techniques (p. 346)	2	W/S	4	J. Kriegseis

Learning Control / Examinations
is according to the chosen course

Conditions
none

Recommendations
none

Learning Outcomes
Students are able to:

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

Content
see chosen laboratory practical

Remarks
One of the training courses has to be chosen.

Module: Compulsory Elective Module Mechanical Engineering [MSc-Modul 04, WF]

Coordination: M. Heilmaier
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
8		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2134150	Analysis of Exhaust Gas und Lubricating Oil in Combustion Engines (p. 65)	2	S	4	M. Gohl, H. Kubach
2154420	Aerodynamics (p. 66)	2	S	4	F. Ohle, B. Frohnapfel
2154436	Aerothermodynamics (p. 67)	2	S	4	F. Seiler, B. Frohnapfel
2141866	Actuators and sensors in nanotechnology (p. 68)	2	W	4	M. Kohl
2145181	Applied Tribology in Industrial Product Development (p. 69)	2	W	4	A. Albers, B. Lorentz
2182614	Applied Materials Modelling (p. 70)	4	S	7	K. Schulz, P. Gumbsch
2113077	Drive Train of Mobile Machines (p. 71)	3	W	4	M. Geimer, M. Scherer, D. Engelmann
2182735	Application of advanced programming languages in mechanical engineering (p. 72)	2	S	4	D. Weygand
2109035	Human Factors Engineering I: Ergonomics (p. 73)	2	W	4	B. Deml
2109036	Human Factors Engineering II: Work Organisation (p. 74)	2	W	4	B. Deml
2181740	Atomistic simulations and molecular dynamics (p. 75)	2	S	4	C. Brandl, P. Gumbsch
2194643	Constitution and Properties of Wear resistant materials (p. 76)	2	S	4	S. Ulrich
2177601	Constitution and Properties of Protective Coatings (p. 77)	2	W	4	S. Ulrich
2118087	Selected Applications of Technical Logistics (p. 78)	3	S	4	M. Mittwollen, V. Milushev
2143892	Selected Topics on Optics and Microoptics for Mechanical Engineers (p. 79)	2	S	4	T. Mappes
2167541	Selected chapters of the combustion fundamentals (p. 80)	2	W/S	4	U. Maas
2190411	Selected Problems of Applied Reactor Physics and Exercises (p. 81)	2	S	4	R. Dagan
2181745	Design of highly stresses components (p. 83)	2	W	4	J. Aktaa
2113079	Design and Development of Mobile Machines (p. 84)	2	W	4	M. Geimer, J. Siebert
2146208	Dimensioning and Optimization of Power Train System (p. 85)	2	S	4	H. Faust
2106005	Automation Systems (p. 86)	2	S	4	M. Kaufmann
2138340	Automotive Vision (eng.) (p. 148)	3	S	6	C. Stiller, M. Lauer
2115919	Rail System Technology (p. 87)	2	W/S	4	P. Gratzfeld
2133108	Fuels and Lubricants for Combustion Engines (p. 89)	2	W	4	B. Kehrwald, H. Kubach

2141864	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I (p. 90)	2	W	4	A. Guber
2142883	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II (p. 91)	2	S	4	A. Guber
2142879	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III (p. 92)	2	S	4	A. Guber
2141102	(p. 93)	2	W	4	A. Guber
2142140	Bionics for Engineers and Natural Scientists (p. 94)	2	S	4	H. Hölscher
2114092	BUS-Controls (p. 95)	2	S	4	M. Geimer
2147175	CAE-Workshop (p. 96)	3	W/S	4	A. Albers, Assistenten
2130910	CFD for Power Engineering (p. 97)	2	S	4	I. Otic
2169461	Coal fired power plants (p. 99)	2	W	4	T. Schulenberg
2105016	Computational Intelligence (p. 100)	2	W	4	R. Mikut, W. Jakob, M. Reischl
2106014	Data Analytics for Engineers (p. 103)	3	S	5	R. Mikut, M. Reischl, J. Stegmaier
2114914	Railways in the Transportation Market (p. 107)	2	S	4	P. Gratzfeld
2153405	Finite Difference Methods for numerial solution of thermal and fluid dynamical problems (p. 108)	2	W	4	C. Günther
2162277	Digital microstructure characterization and modeling (p. 109)	4	S	6	M. Schneider
2137309	Digital Control (p. 110)	2	W	4	M. Knoop
2163111	Dynamics of the Automotive Drive Train (p. 114)	4	W	5	A. Fidlin
2162282	Introduction to the Finite Element Method (p. 115)	4	S	5	T. Böhlke
2189903	Introduction to Nuclear Energy (p. 116)	2	W	4	X. Cheng
2182732	Introduction to Theory of Materials (p. 117)	2	S	4	M. Kamlah
2105011	Introduction into Mechatronics (p. 118)	3	W	6	M. Reischl, M. Lorch
2162235	Introduction into the multi-body dynamics (p. 119)	3	S	5	W. Seemann
2162247	Introduction to Nonlinear Vibrations (p. 121)	4	W	7	A. Fidlin
2114346	Electric Rail Vehicles (p. 125)	2	S	4	P. Gratzfeld
2117096	Elements of Technical Logistics (p. 127)	3	W	4	M. Mittwollen, G. Fischer
2117097	Elements of Technical Logistics - Project (p. 128)	4	W	2	M. Mittwollen, G. Fischer
2117500	Energy efficient intralogistic systems (p. 129)	2	W	4	M. Braun, F. Schönung
2189487	Energy Storage and Network Integration (p. 130)	2	W	4	R. Stieglitz, W. Jaeger, Jäger, Noe
2129901	Energy Systems I: Renewable Energy (p. 132)	3	W	6	R. Dagan
2181731	Fatigue of Welded Components and Structures (p. 133)	2	W	4	M. Farajian, P. Gumbsch,
2106008	Organ support systems (p. 134)	2	S	4	C. Pylatiuk
2154446	Experimental Fluid Mechanics (p. 135)	2	S	4	J. Kriegseis

2190920	Experimental techniques in thermo- and fluid-dynamics (p. 137)	2	S	4	X. Cheng
2113807	Handling Characteristics of Motor Vehicles I (p. 138)	2	W	4	H. Unrau
2114838	Handling Characteristics of Motor Vehicles II (p. 139)	2	S	4	H. Unrau
2113806	Vehicle Comfort and Acoustics I (p. 141)	2	W	4	F. Gauterin
2114825	Vehicle Comfort and Acoustics II (p. 143)	2	S	4	F. Gauterin
2113102	Vehicle Lightweight design – Strategies, Concepts, Materials (p. 145)	2	W	4	F. Henning
2113816	Vehicle Mechatronics I (p. 146)	2	W	4	D. Ammon
2114845	Tires and Wheel Development for Passenger Cars (p. 147)	2	S	4	G. Leister
2114053	Composite Manufacturing – Polymers, Fibers, Semi-Finished Products, Manufacturing Technologies (p. 149)	2	S	4	F. Henning
2183716	FEM Workshop – constitutive laws (p. 150)	2	W/S	4	K. Schulz, D. Weygand
2143882	Fabrication Processes in Microsystem Technology (p. 151)	2	W/S	4	K. Bade
2193003	Solid State Reactions and Kinetics of Phase Transformations (with exercises) (p. 152)	2	W	4	P. Franke
2154431	Finite Volume Methods for Fluid Flow (p. 153)	2	S	4	C. Günther
2154401	Fluid-Structure-Interaction (p. 154)	2	S	4	M. Mühlhausen, B. Frohnapfel
2114093	Fluid Technology (p. 155)	4	W	5	M. Geimer, M. Scherer, L. Brinkschulte
3165016	Fundamentals of Combustion I (p. 179)	2	W	4	U. Maas, J. Sommerer
2169483	Fusion Technology A (p. 156)	2	W	4	R. Stieglitz, Fietz, Day, Boccaccini
2190492	Fusion Technology B (p. 157)	2	S	4	R. Stieglitz, Fischer, Möslang, Gantenbein
2170490	Combined Cycle Power Plants (p. 158)	2	S	4	T. Schulenberg
2154200	Gasdynamics (p. 159)	2	W	4	F. Magagnato
2134141	Gas Engines (p. 160)	2	S	4	R. Golloch
2178124	Microstructure Characteristics Relationships (p. 161)	3	S	6	P. Gruber
2174575	Foundry Technology (p. 162)	2	S	4	C. Wilhelm
2149610	Global Production and Logistics - Part 1: Global Production (p. 163)	2	W	4	G. Lanza
2149600	Global Production and Logistics - Part 2: Global Logistics (p. 165)	2	S	4	K. Furmans, O. Zimmermann
2114835	Automotive Engineering II (p. 168)	2	S	4	H. Unrau
2193010	Basic principles of powder metallurgical and ceramic processing (p. 169)	2	W	4	G. Schell, R. Oberacker
2134138	Fundamentals of catalytic exhaust gas aftertreatment (p. 170)	2	S	4	E. Lox, H. Kubach, O. Deutschmann, J. Grunwaldt
2105992	Principles of Medicine for Engineers (p. 171)	2	W	4	C. Pylatiuk

2141861	Introduction to Microsystem Technology I (p. 172)	2	W	4	J. Korvink, V. Badilita, M. Jouda
2142874	Introduction to Microsystem Technology II (p. 174)	2	S	4	J. Korvink, M. Jouda
2181720	Foundations of nonlinear continuum mechanics (p. 176)	2	W	4	M. Kamlah
2141007	Fundamentals of X-ray Optics I (p. 177)	2	W	4	A. Last
2117095	Basics of Technical Logistics (p. 178)	4	W	6	M. Mittwollen, J. Oellerich
2165515	Fundamentals of Combustion I (p. 180)	2	W	4	U. Maas
2166538	Fundamentals of Combustion II (p. 181)	2	S	4	U. Maas
2153410	Optical Flow Measurement: Fundamentals and Applications (p. 182)	2	W	4	F. Seiler, B. Frohnapfel
2143874	Hands-on BioMEMS (p. 183)	2	W/S	4	A. Guber, T. Rajabi, R. Ahrens
2183721	High Performance Computing (p. 185)	3	W/S	5	B. Nestler, M. Selzer
2174600	High Temperature Materials (p. 187)	2	W	4	M. Heilmaier
2109021	Human-oriented Productivity Management: Personnel Management (p. 188)	2	W	4	P. Stock
2154437	Hydrodynamic Stability: From Order to Chaos (p. 190)	2	S	4	A. Class
2153425	Industrial aerodynamics (p. 191)	2	W	4	T. Breitling, B. Frohnapfel
2109042	Introduction to Industrial Production Economics (p. 192)	2	W	4	S. Dürrschnabel
2110037	Occupational Safety and Environmental Protection (in German) (p. 193)	2	S	4	R. von Kiparski
2118094	Information Systems in Logistics and Supply Chain Management (p. 195)	2	S	4	C. Kilger
2130973	Innovative Nuclear Systems (p. 196)	2	S	4	X. Cheng
2190490	Introduction to Neutron Cross Section Theory and Nuclear Data Generation (p. 197)	2	S	4	R. Dagan
2118183	IT-Fundamentals of Logistics (p. 198)	2	S	4	F. Thomas
2125757	Introduction to Ceramics (p. 199)	4	W	6	M. Hoffmann
2126730	Ceramics Processing (p. 200)	2	S	4	J. Binder
2170460	Nuclear Power Plant Technology (p. 201)	2	S	4	T. Schulenberg, K. Litfin
2174571	Design with Plastics (p. 203)	2	S	4	M. Liedel
2174580	Structural Materials (p. 204)	4	S	6	K. Lang
2146190	Lightweight Engineering Design (p. 205)	2	S	4	A. Albers, N. Burkardt
2181220	Contact Mechanics (p. 206)	2	S	4	C. Greiner
2170463	Cooling of thermally high loaded gas turbine components (p. 208)	2	S	4	H. Bauer, A. Schulz
2118097	Warehousing and distribution systems (p. 210)	2	S	4	K. Furmans
2182642	Laser in automotive engineering (p. 212)	2	S	4	J. Schneider

2145184	Leadership and Management Development (p. 213)	2	W	4	A. Ploch
2118078	Logistics - organisation, design and control of logistic systems (p. 216)	4	S	6	K. Furmans
2118085	Automotive Logistics (p. 217)	2	S	4	K. Furmans
2117056	Airport logistics (p. 218)	2	W	4	A. Richter
2190496	Magnet Technology of Fusion Reactors (p. 220)	2	S	4	W. Fietz, K. Weiss
2153429	Magnetohydrodynamics (p. 221)	3	W	6	L. Bühler
2110017	Leadership and Conflict Management (in German) (p. 222)	2	S	4	H. Hatzl
2162220	Machine Dynamics II (p. 224)	2	W	4	C. Proppe
2149669	Materials and Processes for Body Lightweight Construction in the Automotive Industry (p. 227)	2	W	4	D. Steegmüller, S. Kienzle
2161206	Mathematical Methods in Dynamics (p. 229)	2	W	5	C. Proppe
2162241	Mathematical methods of vibration theory (p. 232)	3	S	5	W. Seemann
2154432	Mathematical Methods in Fluid Mechanics (p. 233)	3	S	6	B. Frohnapfel, D. Gatti
2165525	Mathematical models and methods in combustion theory (p. 236)	2	W	4	V. Bykov, U. Maas
2117059	Mathematical models and methods for Production Systems (p. 237)	4	W	6	K. Furmans, M. Rimmele
2173580	Mechanics and Strength of Polymers (p. 240)	2	W	4	B. Graf von Bernstorff
2181710	Mechanics in Microtechnology (p. 241)	2	W	4	P. Gruber, C. Greiner
2138326	Measurement II (p. 243)	2	S	4	C. Stiller
2174598	Metals (p. 245)	4	S	6	M. Heilmaier
2134134	Analysis tools for combustion diagnostics (p. 249)	2	S	4	J. Pfeil
2142897	Microenergy Technologies (p. 250)	2	S	4	M. Kohl
2141501	Micro Magnetic Resonannce (p. 251)	2	W	4	J. Korvink, N. MacKinnon
2142881	Microactuators (p. 252)	2	S	4	M. Kohl
2161251	Microstructure characterization and modelling (p. 253)	2	W	5	T. Böhlke, F. Fritzen
2183702	Modelling of Microstructures (p. 254)	3	W	5	A. August, B. Nestler, D. Weygand
2134139	Model based Application Methods (p. 255)	3	S	4	F. Kirschbaum
2167523	Modeling of Thermodynamical Processes (p. 257)	3	W/S	6	R. Schießl, U. Maas
2183703	Numerical methods and simulation techniques (p. 258)	3	W/S	5	B. Nestler
2134137	Engine measurement techniques (p. 263)	2	S	4	S. Bernhardt
2142861	Nanotechnology for Engineers and Natural Scientists (p. 265)	2	S	4	H. Hölscher, M. Dienwiebel, S. Walheim
2182712	Nanotribology and -Mechanics (p. 267)	2	W/S	4	M. Dienwiebel
2141103	Neurovascular Interventions (Bio-MEMS V) (p. 270)	2	W	4	A. Guber, G. Cattaneo
2189473	Neutron physics of fusion reactors (p. 271)	2	W	4	U. Fischer

2162344	Nonlinear Continuum Mechanics (p. 272)	2	S	5	T. Böhlke
2130934	Numerical Modeling of Multiphase Flows (p. 277)	2	S	4	M. Wörner
2169458	Numerical simulation of reacting two phase flows (p. 278)	2	W	4	R. Koch
2153449	Numerical Simulation of Turbulent Flows (p. 279)	3	W	4	G. Grötzbach
2153441	Numerical Fluid Mechanics (p. 280)	2	W	4	F. Magagnato
2147161	Intellectual Property Rights and Strategies in Industrial Companies (p. 282)	2	W/S	4	F. Zacharias
2142890	Physics for Engineers (p. 285)	2	S	4	P. Gumbsch, A. Nesterov-Müller, D. Weygand, T. Förtsch
2181612	Physical basics of laser technology (p. 287)	3	W	4	J. Schneider
2109034	Planning of Assembly Systems (in German) (p. 289)	2	W	4	E. Haller
2181750	Multi-scale Plasticity (p. 290)	2	W	4	K. Schulz, C. Greiner
2122376	PLM for Product Development in Mechatronics (p. 291)	2	S	4	M. Eigner
2121366	PLM in the Manufacturing Industry (p. 292)	2	W	4	G. Meier
2173590	Polymer Engineering I (p. 294)	2	W	4	P. Elsner
2174596	Polymer Engineering II (p. 295)	2	S	4	P. Elsner
2141853	Polymers in MEMS A: Chemistry, Synthesis and Applications (p. 296)	2	W	4	B. Rapp
2141854	Polymers in MEMS B: Physics, Microstructuring and Applications (p. 298)	2	W	4	M. Worgull
2142855	(p. 300)	2	S	4	M. Worgull, B. Rapp
2121350	Product Lifecycle Management (p. 305)	3	W	4	J. Ovtcharova, T. Maier
2123364	Product, Process and Resource Integration in the Automotive Industry (p. 307)	3	S	4	S. Mbang
2110032	Production Planning and Control (p. 309)	2	W	4	A. Rinn
2110046	Productivity Management in Production Systems (p. 312)	2	S	4	S. Stowasser
2115817	Project Workshop: Automotive Engineering (p. 313)	3	W/S	6	F. Gauterin, M. Gießler, M. Frey
2149680	Project Mikro Manufacturing: Design and Manufacturing of Micro Systems (p. 314)	3	W	6	V. Schulze, B. Matuschka, A. Kacaras
2113072	Development of Oil-Hydraulic Powertrain Systems (p. 315)	2	W	4	G. Geerling, S. Becker
2115995	Project Management in Rail Industry (p. 316)	2	W	4	P. Gratzfeld
2145182	Project management in Global Product Engineering Structures (p. 317)	2	W	4	P. Gutzmer
2161501	Process Simulation in Forming Operations (p. 319)	2	W	4	D. Helm
2126749	Advanced powder metals (p. 320)	2	S	4	R. Oberacker
2149667	Quality Management (p. 321)	2	W	4	G. Lanza

2189465	Reactor Safety I: Fundamentals (p. 323)	2	S	4	V. Sánchez-Espinoza
2162256	Computational Vehicle Dynamics (p. 324)	2	S	4	C. Proppe
2162216	Computerized Multibody Dynamics (p. 325)	2	S	4	W. Seemann
2161250	Computational Mechanics I (p. 326)	4	W	6	T. Böhlke, T. Langhoff
2162296	Computational Mechanics II (p. 327)	4	S	6	T. Böhlke, T. Langhoff
2166543	Reduction methods for the modeling and the simulation of combustion processes (p. 328)	2	S	4	V. Bykov, U. Maas
2182572	Failure Analysis (p. 329)	2	W	4	C. Greiner, J. Schneider
2115996	Rail Vehicle Technology (p. 330)	2	W/S	4	P. Gratzfeld
2173585	Fatigue of Metallic Materials (p. 331)	2	W	4	K. Lang
2117061	Safety Engineering (p. 334)	2	W	4	H. Kany
2114095	Simulation of Coupled Systems (p. 336)	4	S	4	M. Geimer
2154044	Scaling in fluid dynamics (p. 338)	2	S	4	L. Bühler
2189400	Solar Thermal Energy Systems (p. 339)	2	W	4	R. Dagan
2163113	Theory of Stability (p. 340)	4	S	6	A. Fidlin
2150683	Control Technology (p. 341)	2	S	4	C. Gönnheimer
2146198	Strategic product development - identification of potentials of innovative products (p. 343)	2	S	4	A. Siebe
2153406	Flows with chemical reactions (p. 344)	2	W	4	A. Class
2189910	Flows and Heat Transfer in Energy Technology (p. 345)	2	W	4	X. Cheng
2125763	Structural and phase analysis (p. 347)	2	W	4	S. Wagner, M. Hinterstein
2126775	Structural Ceramics (p. 348)	2	S	4	M. Hoffmann
2177618	Superhard Thin Film Materials (p. 350)	2	W	4	S. Ulrich
2117062	Supply chain management (p. 351)	4	W	6	K. Alicke
2146192	Sustainable Product Engineering (p. 352)	2	S	4	K. Ziegahn
2158107	Technical Acoustics (p. 356)	2	S	4	M. Gabi
2106002	Computer Engineering (p. 358)	3	S	6	M. Lorch, H. Keller
2121001	Integrated Information Systems for engineers (p. 360)	3	S	4	J. Ovtcharova
2146179	Technical Design in Product Development (p. 363)	2	S	4	M. Schmid
2174579	Technology of steel components (p. 365)	2	S	4	V. Schulze
2189904	Ten lectures on turbulence (p. 366)	2	W	4	I. Otic
2194650	Materials under high thermal or neutron loads (p. 367)	2	S	4	A. Möslang, J. Reiser
2157445	Computational methods for the heat protection of a full vehicle (p. 368)	2	W	4	H. Reister
2169472	Thermal Solar Energy (p. 369)	2	W	4	R. Stieglitz
2169453	Thermal Turbomachines I (p. 371)	3	W	6	H. Bauer
2170476	Thermal Turbomachines II (p. 373)	3	S	6	H. Bauer
2193002	Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises) (p. 374)	2	W	5	H. Seifert

2189423	Thermal-Fluid-Dynamics (p. 375)	2	W	4	S. Ruck
2113080	Tractors (p. 376)	2	W	4	M. Kremmer, M. Scherer
2169462	Turbine and compressor Design (p. 377)	2	W	4	H. Bauer, A. Schulz
2170478	Turbo Jet Engines (p. 378)	2	S	4	H. Bauer, A. Schulz
2150681	Metal Forming (p. 379)	2	S	4	T. Herlan
2167048	Combustion diagnositics (p. 380)	2	W/S	4	R. Schießl, U. Maas
2138336	Behaviour Generation for Vehicles (p. 381)	2	S	4	C. Stiller, M. Werling
2181715	Failure of Structural Materials: Fatigue and Creep (p. 382)	2	W	4	P. Gruber, P. Gumbsch, O. Kraft
2181711	Failure of structural materials: deformation and fracture (p. 383)	3	W	4	P. Gumbsch, D. Weygand, O. Kraft
2149655	Gear Cutting Technology (p. 385)	2	W	4	M. Klaiber
3122031	Virtual Engineering (Specific Topics) (p. 82)	2	S	4	J. Ovtcharova
2121352	Virtual Engineering I (p. 387)	4	W	4	J. Ovtcharova
2122378	Virtual Engineering II (p. 388)	3	S	4	J. Ovtcharova
2166534	Heatpumps (p. 390)	2	S	4	H. Wirbser, U. Maas
2189907	Heat Transfer in Nuclear Reactors (p. 391)	2	W	4	X. Cheng
2170495	Hydrogen Technologies (p. 393)	2	S	4	T. Jordan
2161219	Wave Propagation (p. 394)	2	W	4	W. Seemann
2174574	Materials for Lightweight Construction (p. 395)	2	S	4	K. Weidenmann
2182740	Materials modelling: dislocation based plasticy (p. 396)	2	S	4	D. Weygand
2181738	Scientific computing for Engineers (p. 397)	2	W	4	D. Weygand, P. Gumbsch
2133125	Ignition systems (p. 400)	2	W	4	O. Toedter
2169470	Two-Phase Flow and Heat Transfer (p. 401)	2	W	4	T. Schulenberg, M. Wörner
2115009	Seminar for Rail System Technology (p. 333)	2	W/S	3	P. Gratzfeld
2110050	Vehicle Ergonomics (p. 140)	2	S	4	T. Heine
2143876	Nanotechnology with Clusterbeams (p. 266)	2	W	4	J. Gspann
2162255	Designing with composites (p. 112)	2	S	4	E. Schnack
2161229	Designing with numerical methods in product development (p. 111)	2	W	4	E. Schnack
2161226	Introducion to numerical mechanics (p. 120)	3	W	4	E. Schnack
2162298	Numerical mechanics for industrial applications (p. 276)	3	S	4	E. Schnack
2161983	Mechanics of laminated composites (p. 239)	2	W	4	E. Schnack
2162240	Mathematical Foundation for Computational Mechanics (p. 228)	2	S	4	E. Schnack

Learning Control / Examinations
oral exam, graded

Conditions
None.

Learning Outcomes
The compulsory elective course module shall provide a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.
The specific learning outcomes are defined by the respective coordinator of the course.

Content
see chosen compulsory elective subjects

Remarks
Compulsory elective subjects have to be chosen from the corresponding catalogues as displayed in the master´s program with an amount of 8 credit points, respectively.
(See Studienplan or Module Handbook)

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

Coordination: A. Class, U. Maas
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
6		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
23620	Hardware/Software Codesign (p. 184)	3	W	6	O. Sander
2153429	Magnetohydrodynamics (p. 221)	3	W	6	L. Bühler
23113	Methods of Signal Processing (p. 246)	3/1	W	6	Puente León
23737	Photovoltaics (p. 284)	3	S	6	M. Powalla
2181612	Physical basics of laser technology (p. 287)	3	W	4	J. Schneider
23109	Signals and Systems (p. 335)	2/1	W	6	F. Puente, F. Puente León
2153406	Flows with chemical reactions (p. 344)	2	W	4	A. Class
23605	Systems and Software Engineering (p. 354)	3	W	6	E. Sax
2106002	Computer Engineering (p. 358)	3	S	6	M. Lorch, H. Keller
2154437	Hydrodynamic Stability: From Order to Chaos (p. 190)	2	S	4	A. Class

Learning Control / Examinations
Please refer to the description of the different courses.

Conditions
None.

Recommendations
None.

Learning Outcomes
After completing the Elective Module "Wahlpflichtmodul" the attendents can explain the fundamentals in a specific subject of science, computer science or electrical engineering.
Detailed learning targets are described in the individual courses.

Content
Please refer to the description of the listed courses.

Remarks
One of the lectures listed above has to be chosen.

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

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

ECTS Credits	Cycle	Duration
4		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2109036	Human Factors Engineering II: Work Organisation (p. 74)	2	W	4	B. Deml
2145184	Leadership and Management Development (p. 213)	2	W	4	A. Ploch
2110017	Leadership and Conflict Management (in German) (p. 222)	2	S	4	H. Hatzl
24016	Public Law I - Basic Principles (p. 281)	2	W	4	G. Sydow
24656	Patent Law (p. 283)	2	S	4	P. Bittner
2149667	Quality Management (p. 321)	2	W	4	G. Lanza

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

Conditions
none

Recommendations
none

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

Content
see chosen subject

Remarks
One of the lectures listed above has to be chosen.
Recommended courses are for instance related to innovation management and interlectual property.

Module: Key Qualifications [MSc-Modul, SQL]

Coordination: M. Heilmaier
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
2		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2101010	ZAK lectures (p. 399)			2	M. Heilmaier
2101011	HoC lectures (p. 186)			2	M. Heilmaier
2149661	Value stream within enterprises – The value chain at Bosch (p. 105)	2	W	2	J. Fleischer, Dr. Rudolf Maier
2109039	Do it! – Service-Learning for prospective mechanical engineers (p. 113)	2	W	4	B. Deml
2114917	Engineer's Field of Work (p. 101)	2	S	2	P. Gratzfeld, M. Doppelbauer

Learning Control / Examinations
s. courses

Conditions
none

Learning Outcomes
s. courses

Content
s. courses

3.3 Specialisation

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

Coordination: M. Heilmaier
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16		

Learning Control / Examinations
oral exam

Conditions
see Studienplan

Learning Outcomes
As part of a major field a domain of mechanical engineering is made accessible in breadth and depth. Students gain comprehensive knowledge in the core subjects and detailed knowledge in the supplementary subjects of the slected domain, where they are able to successfully carry out complex projects as well as to develop and implement innovations.
The specific learning outcomes are defined by the respective coordinator of the major field.

Content
see chosen major field

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

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

Coordination: M. Heilmaier
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
16		

Learning Control / Examinations
oral exam

Conditions
see Studienplan

Learning Outcomes
As part of a major field a domain of mechanical engineering is made accessible in breadth and depth. Students gain comprehensive knowledge in the core subjects and detailed knowledge in the supplementary subjects of the slected domain, where they are able to successfully carry out complex projects as well as to develop and implement innovations.
The specific learning outcomes are defined by the respective coordinator of the major field.

Content
see chosen major field

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

Module: Master Thesis [MSc-AA]

Coordination: M. Heilmaier
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
30	Every term	1

Learning Control / Examinations
The module Master Thesis consists of a written master thesis and an oral presentation of a scientific subject chosen by the student himself/herself or given by the supervisor. The master's thesis is designed to show that the student is able to deal with a problem of his/her subject area in an independent manner and within the given period of time using scientific methods.
The scope of the master thesis corresponds to 12 ECTS. The maximal processing time of the master thesis takes three months. The examination board defines the languages the thesis has to be written in. With consent of the examiner the thesis can be written in another language than German as well. The date of issue of the subject has to be fixed by the supervisor and the student and to be put on record at the examination board. The subject of the master thesis may be only returned once and only within the first month of processing time
On a reasoned request of the student, the examination board can extend the processing time by up to one month. If the master thesis is not completed in time, this examination is "failed" (5,0), unless the student is not responsible. The master thesis is to be evaluated by not less than a professor or a senior scientist according to § 14 Abs. 3 Ziff. 1 KITG and another examiner. Generally, one of the two examiners is the person who has assigned the thesis. If the examiners do not agree, the master thesis is graded by the examination board within this assessment; another expert can be appointed too. The master thesis has to be graded within a period of six weeks after the submission. The colloquium presentation must be held within 6 weeks after the submission of the master thesis. The presentation should last around 20 minutes followed by a scientific discussion with the present expert audience. The performance in the presentation and subsequent discussion will be evaluated and graded and will be included in the overall grade of the master module in accordance with the weighted credit points (3LP).
The learning control is described in detail in § 14 SPO.

Conditions
The requirement for admission to the master's thesis module are 74 ECTS. As to exceptions, the examination board decides on a request of the student (see § 14 (1) SPO).

Learning Outcomes
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's thesis. The topic is set by the supervisor of the thesis in accordance with § 14 (3) SPO.

3.4 Fundamentals and Methods of Specialisation

Module: Fundamentals and Methods of General Mechanical Engineering [MSc-Modul MB, WPF MB]

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

ECTS Credits	Cycle	Duration
8		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2109035	Human Factors Engineering I: Ergonomics (p. 73)	2	W	4	B. Deml
2147175	CAE-Workshop (p. 96)	3	W/S	4	A. Albers, Assistenten
2105011	Introduction into Mechatronics (p. 118)	3	W	6	M. Reischl, M. Lorch
2162235	Introduction into the multi-body dynamics (p. 119)	3	S	5	W. Seemann
2114093	Fluid Technology (p. 155)	4	W	5	M. Geimer, M. Scherer, L. Brinkschulte
2141861	Introduction to Microsystem Technology I (p. 172)	2	W	4	J. Korvink, V. Badilita, M. Jouda
2142874	Introduction to Microsystem Technology II (p. 174)	2	S	4	J. Korvink, M. Jouda
2117095	Basics of Technical Logistics (p. 178)	4	W	6	M. Mittwollen, J. Oellerich
2165515	Fundamentals of Combustion I (p. 180)	2	W	4	U. Maas
2161224	Machine Dynamics (p. 223)	3	S	5	C. Proppe
2161206	Mathematical Methods in Dynamics (p. 229)	2	W	5	C. Proppe
2161254	Mathematical Methods in Strength of Materials (p. 230)	3	W	5	T. Böhlke
2162241	Mathematical methods of vibration theory (p. 232)	3	S	5	W. Seemann
2154432	Mathematical Methods in Fluid Mechanics (p. 233)	3	S	6	B. Frohnapfel, D. Gatti
2162280	Mathematical Methods in Structural Mechanics (p. 234)	3	S	5	T. Böhlke
2117059	Mathematical models and methods for Production Systems (p. 237)	4	W	6	K. Furmans, M. Rimmele
2183702	Modelling of Microstructures (p. 254)	3	W	5	A. August, B. Nestler, D. Weygand
2183703	Numerical methods and simulation techniques (p. 258)	3	W/S	5	B. Nestler
4040311	Modern Physics for Engineers (p. 261)	2	S	5	B. Pilawa
2141865	Novel actuators and sensors (p. 268)	2	W	4	M. Kohl, M. Sommer
2181612	Physical basics of laser technology (p. 287)	3	W	4	J. Schneider
2142890	Physics for Engineers (p. 285)	2	S	4	P. Gumbsch, A. Nesterov-Müller, D. Weygand, T. Förtsch

2121350	Product Lifecycle Management (p. 305)	3	W	4	J. Ovtcharova, T. Maier
2174576	Systematic Materials Selection (p. 353)	3	S	5	S. Dietrich
2133123	Fundamentals of Combustion Engine Technology (p. 357)	2	W	5	S. Bernhardt, H. Kubach, J. Pfeil, O. Toedter, U. Wagner, A. Velji
2121001	Integrated Information Systems for engineers (p. 360)	3	S	4	J. Ovtcharova
2161212	Vibration Theory (p. 361)	3	W	5	A. Fidlin
2165512	Heat and Mass Transfer (p. 389)	2	W	4	U. Maas
2181738	Scientific computing for Engineers (p. 397)	2	W	4	D. Weygand, P. Gumbsch

Learning Control / Examinations
2 individual exams: written or oral, graded

Conditions
See Studienplan

Learning Outcomes
The course “Grundlagen und Methoden des Maschinenbaus” serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.
The specific learning outcomes are defined by the respective coordinator of the course.

Content
see chosen course

Remarks
none

Module: Fundamentals and Methods of Energy and Environmental Engineering [MSc-Modul E+U, WPF E+U]

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

ECTS Credits	Cycle	Duration
8		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2165512	Heat and Mass Transfer (p. 389)	2	W	4	U. Maas
2147175	CAE-Workshop (p. 96)	3	W/S	4	A. Albers, Assistenten
2105011	Introduction into Mechatronics (p. 118)	3	W	6	M. Reischl, M. Lorch
2162235	Introduction into the multi-body dynamics (p. 119)	3	S	5	W. Seemann
2114093	Fluid Technology (p. 155)	4	W	5	M. Geimer, M. Scherer, L. Brinkschulte
2117095	Basics of Technical Logistics (p. 178)	4	W	6	M. Mittwollen, J. Oellerich
2165515	Fundamentals of Combustion I (p. 180)	2	W	4	U. Maas
2161224	Machine Dynamics (p. 223)	3	S	5	C. Proppe
2154432	Mathematical Methods in Fluid Mechanics (p. 233)	3	S	6	B. Frohnapfel, D. Gatti
4040311	Modern Physics for Engineers (p. 261)	2	S	5	B. Pilawa
2141865	Novel actuators and sensors (p. 268)	2	W	4	M. Kohl, M. Sommer
0187400	Numerical Mathematics (p. 275)	3	S	6	C. Wieners, D. Weiß, Neuß, Rieder
2142890	Physics for Engineers (p. 285)	2	S	4	P. Gumbsch, A. Nesterov-Müller, D. Weygand, T. Förtsch
2181612	Physical basics of laser technology (p. 287)	3	W	4	J. Schneider
2174576	Systematic Materials Selection (p. 353)	3	S	5	S. Dietrich
2133123	Fundamentals of Combustion Engine Technology (p. 357)	2	W	5	S. Bernhardt, H. Kubach, J. Pfeil, O. Toedter, U. Wagner, A. Velji
2161212	Vibration Theory (p. 361)	3	W	5	A. Fidlin

Learning Control / Examinations
2 individual exams: written or oral, graded

Conditions
See Studienplan

Learning Outcomes
The course “Grundlagen und Methoden der Energie- und Umwelttechnik” serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.
The specific learning outcomes are defined by the respective coordinator of the course.

Content
see chosen course

Remarks
none

Module: Fundamentals and Methods of Automotive Engineering [MSc-Modul FzgT, WPF FzgT]

Coordination: F. Gauterin
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
8		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2147175	CAE-Workshop (p. 96)	3	W/S	4	A. Albers, Assistenten
2105011	Introduction into Mechatronics (p. 118)	3	W	6	M. Reischl, M. Lorch
2162235	Introduction into the multi-body dynamics (p. 119)	3	S	5	W. Seemann
23224	Electrical Engineering II (p. 126)	3	S	5	W. Menesklou
2114093	Fluid Technology (p. 155)	4	W	5	M. Geimer, M. Scherer, L. Brinkschulte
2117095	Basics of Technical Logistics (p. 178)	4	W	6	M. Mittwollen, J. Oellerich
2165515	Fundamentals of Combustion I (p. 180)	2	W	4	U. Maas
2161224	Machine Dynamics (p. 223)	3	S	5	C. Proppe
2161206	Mathematical Methods in Dynamics (p. 229)	2	W	5	C. Proppe
2161254	Mathematical Methods in Strength of Materials (p. 230)	3	W	5	T. Böhlke
2162241	Mathematical methods of vibration theory (p. 232)	3	S	5	W. Seemann
2154432	Mathematical Methods in Fluid Mechanics (p. 233)	3	S	6	B. Frohnapfel, D. Gatti
4040311	Modern Physics for Engineers (p. 261)	2	S	5	B. Pilawa
2141865	Novel actuators and sensors (p. 268)	2	W	4	M. Kohl, M. Sommer
0187400	Numerical Mathematics (p. 275)	3	S	6	C. Wieners, D. Weiß, Neuß, Rieder
2181612	Physical basics of laser technology (p. 287)	3	W	4	J. Schneider
2142890	Physics for Engineers (p. 285)	2	S	4	P. Gumbsch, A. Nesterov-Müller, D. Weygand, T. Förtsch
2121350	Product Lifecycle Management (p. 305)	3	W	4	J. Ovtcharova, T. Maier
2174576	Systematic Materials Selection (p. 353)	3	S	5	S. Dietrich
2133123	Fundamentals of Combustion Engine Technology (p. 357)	2	W	5	S. Bernhardt, H. Kubach, J. Pfeil, O. Toedter, U. Wagner, A. Velji
2121001	Integrated Information Systems for engineers (p. 360)	3	S	4	J. Ovtcharova
2161212	Vibration Theory (p. 361)	3	W	5	A. Fidlin
0186000	Probability Theory and Statistics (p. 392)	3	S	5	D. Hug

2165512	Heat and Mass Transfer (p. 389)	2	W	4	U. Maas

Learning Control / Examinations
2 individual exams: written or oral, graded

Conditions
See Studienplan

Learning Outcomes
The course "Grundlagen und Methoden der Fahrzeugtechnik" serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.
The specific learning outcomes are defined by the respective coordinator of the course.

Content
see chosen course

Remarks
none

Module: Fundamentals and Methods of Mechatronics and Microsystem Technology [MSc-Modul M+M, WPF M+M]

Coordination: J. Korvink
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
8		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2105011	Introduction into Mechatronics (p. 118)	3	W	6	M. Reischl, M. Lorch
2147175	CAE-Workshop (p. 96)	3	W/S	4	A. Albers, Assistenten
2162235	Introduction into the multi-body dynamics (p. 119)	3	S	5	W. Seemann
2141861	Introduction to Microsystem Technology I (p. 172)	2	W	4	J. Korvink, V. Badilita, M. Jouda
2142874	Introduction to Microsystem Technology II (p. 174)	2	S	4	J. Korvink, M. Jouda
2117095	Basics of Technical Logistics (p. 178)	4	W	6	M. Mittwollen, J. Oellerich
2165515	Fundamentals of Combustion I (p. 180)	2	W	4	U. Maas
2161224	Machine Dynamics (p. 223)	3	S	5	C. Proppe
2161206	Mathematical Methods in Dynamics (p. 229)	2	W	5	C. Proppe
2161254	Mathematical Methods in Strength of Materials (p. 230)	3	W	5	T. Böhlke
2162241	Mathematical methods of vibration theory (p. 232)	3	S	5	W. Seemann
2162280	Mathematical Methods in Structural Mechanics (p. 234)	3	S	5	T. Böhlke
4040311	Modern Physics for Engineers (p. 261)	2	S	5	B. Pilawa
2141865	Novel actuators and sensors (p. 268)	2	W	4	M. Kohl, M. Sommer
0187400	Numerical Mathematics (p. 275)	3	S	6	C. Wieners, D. Weiß, Neuß, Rieder
2181612	Physical basics of laser technology (p. 287)	3	W	4	J. Schneider
2142890	Physics for Engineers (p. 285)	2	S	4	P. Gumbsch, A. Nesterov-Müller, D. Weygand, T. Förtsch
2121350	Product Lifecycle Management (p. 305)	3	W	4	J. Ovtcharova, T. Maier
2174576	Systematic Materials Selection (p. 353)	3	S	5	S. Dietrich
2133123	Fundamentals of Combustion Engine Technology (p. 357)	2	W	5	S. Bernhardt, H. Kubach, J. Pfeil, O. Toedter, U. Wagner, A. Velji
2121001	Integrated Information Systems for engineers (p. 360)	3	S	4	J. Ovtcharova
2161212	Vibration Theory (p. 361)	3	W	5	A. Fidlin

0186000	Probability Theory and Statistics (p. 392)	3	S	5	D. Hug
2165512	Heat and Mass Transfer (p. 389)	2	W	4	U. Maas

Learning Control / Examinations
2 individual exams: written or oral, graded

Conditions
See Studienplan

Learning Outcomes
The course “Grundlagen und Methoden der Mechatronik und Mikrosystemtechnik” serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.
The specific learning outcomes are defined by the respective coordinator of the course.

Content
see chosen course

Remarks
none

Module: Fundamentals and Methods of Product Development and Construction [MSc-Modul PEK, WPF PEK]

Coordination: A. Albers
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
8		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2109035	Human Factors Engineering I: Ergonomics (p. 73)	2	W	4	B. Deml
2147175	CAE-Workshop (p. 96)	3	W/S	4	A. Albers, Assistenten
2105011	Introduction into Mechatronics (p. 118)	3	W	6	M. Reischl, M. Lorch
2162235	Introduction into the multi-body dynamics (p. 119)	3	S	5	W. Seemann
2114093	Fluid Technology (p. 155)	4	W	5	M. Geimer, M. Scherer, L. Brinkschulte
2141861	Introduction to Microsystem Technology I (p. 172)	2	W	4	J. Korvink, V. Badilita, M. Jouda
2142874	Introduction to Microsystem Technology II (p. 174)	2	S	4	J. Korvink, M. Jouda
2117095	Basics of Technical Logistics (p. 178)	4	W	6	M. Mittwollen, J. Oellerich
2161224	Machine Dynamics (p. 223)	3	S	5	C. Proppe
2161206	Mathematical Methods in Dynamics (p. 229)	2	W	5	C. Proppe
2161254	Mathematical Methods in Strength of Materials (p. 230)	3	W	5	T. Böhlke
2162241	Mathematical methods of vibration theory (p. 232)	3	S	5	W. Seemann
2154432	Mathematical Methods in Fluid Mechanics (p. 233)	3	S	6	B. Frohnapfel, D. Gatti
2162280	Mathematical Methods in Structural Mechanics (p. 234)	3	S	5	T. Böhlke
2141865	Novel actuators and sensors (p. 268)	2	W	4	M. Kohl, M. Sommer
2181612	Physical basics of laser technology (p. 287)	3	W	4	J. Schneider
2121350	Product Lifecycle Management (p. 305)	3	W	4	J. Ovtcharova, T. Maier
2174576	Systematic Materials Selection (p. 353)	3	S	5	S. Dietrich
2133123	Fundamentals of Combustion Engine Technology (p. 357)	2	W	5	S. Bernhardt, H. Kubach, J. Pfeil, O. Toedter, U. Wagner, A. Velji
2121001	Integrated Information Systems for engineers (p. 360)	3	S	4	J. Ovtcharova
2161212	Vibration Theory (p. 361)	3	W	5	A. Fidlin
2165512	Heat and Mass Transfer (p. 389)	2	W	4	U. Maas

Learning Control / Examinations
2 individual exams: written or oral, graded

Conditions
See Studienplan

Learning Outcomes
The course “Grundlagen und Methoden der Produktentwicklung und Konstruktion” serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.
The specific learning outcomes are defined by the respective coordinator of the course.

Content
see chosen course

Remarks
none

Module: Fundamentals and Methods of Production Technology [MSc-Modul PT, WPF PT]

Coordination: V. Schulze
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
8		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2109035	Human Factors Engineering I: Ergonomics (p. 73)	2	W	4	B. Deml
2147175	CAE-Workshop (p. 96)	3	W/S	4	A. Albers, Assistenten
2105011	Introduction into Mechatronics (p. 118)	3	W	6	M. Reischl, M. Lorch
2162235	Introduction into the multi-body dynamics (p. 119)	3	S	5	W. Seemann
2114093	Fluid Technology (p. 155)	4	W	5	M. Geimer, M. Scherer, L. Brinkschulte
2141861	Introduction to Microsystem Technology I (p. 172)	2	W	4	J. Korvink, V. Badilita, M. Jouda
2142874	Introduction to Microsystem Technology II (p. 174)	2	S	4	J. Korvink, M. Jouda
2117095	Basics of Technical Logistics (p. 178)	4	W	6	M. Mittwollen, J. Oellerich
2161224	Machine Dynamics (p. 223)	3	S	5	C. Proppe
2161254	Mathematical Methods in Strength of Materials (p. 230)	3	W	5	T. Böhlke
2117059	Mathematical models and methods for Production Systems (p. 237)	4	W	6	K. Furmans, M. Rimmele
2183703	Numerical methods and simulation techniques (p. 258)	3	W/S	5	B. Nestler
2141865	Novel actuators and sensors (p. 268)	2	W	4	M. Kohl, M. Sommer
0187400	Numerical Mathematics (p. 275)	3	S	6	C. Wieners, D. Weiß, Neuß, Rieder
2181612	Physical basics of laser technology (p. 287)	3	W	4	J. Schneider
2121350	Product Lifecycle Management (p. 305)	3	W	4	J. Ovtcharova, T. Maier
2174576	Systematic Materials Selection (p. 353)	3	S	5	S. Dietrich
2121001	Integrated Information Systems for engineers (p. 360)	3	S	4	J. Ovtcharova
2161212	Vibration Theory (p. 361)	3	W	5	A. Fidlin

Learning Control / Examinations
2 individual exams: written or oral, graded

Conditions
See Studienplan

Learning Outcomes
The course “Grundlagen und Methoden der Produktionstechnik” serves as a comprehensive, in-depth analysis of

fundamentals in selected areas of mechanical engineering.
The specific learning outcomes are defined by the respective coordinator of the course.

Content
see chosen course

Remarks
none

Module: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering [MSc-Modul ThM, WPF ThM]

Coordination: T. Böhlke
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
8		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2162235	Introduction into the multi-body dynamics (p. 119)	3	S	5	W. Seemann
2114093	Fluid Technology (p. 155)	4	W	5	M. Geimer, M. Scherer, L. Brinkschulte
2117095	Basics of Technical Logistics (p. 178)	4	W	6	M. Mittwollen, J. Oellerich
2165515	Fundamentals of Combustion I (p. 180)	2	W	4	U. Maas
2161224	Machine Dynamics (p. 223)	3	S	5	C. Proppe
2161206	Mathematical Methods in Dynamics (p. 229)	2	W	5	C. Proppe
2161254	Mathematical Methods in Strength of Materials (p. 230)	3	W	5	T. Böhlke
2162241	Mathematical methods of vibration theory (p. 232)	3	S	5	W. Seemann
2154432	Mathematical Methods in Fluid Mechanics (p. 233)	3	S	6	B. Frohnapfel, D. Gatti
2162280	Mathematical Methods in Structural Mechanics (p. 234)	3	S	5	T. Böhlke
2117059	Mathematical models and methods for Production Systems (p. 237)	4	W	6	K. Furmans, M. Rimmele
2183702	Modelling of Microstructures (p. 254)	3	W	5	A. August, B. Nestler, D. Weygand
2183703	Numerical methods and simulation techniques (p. 258)	3	W/S	5	B. Nestler
4040311	Modern Physics for Engineers (p. 261)	2	S	5	B. Pilawa
0187400	Numerical Mathematics (p. 275)	3	S	6	C. Wieners, D. Weiß, Neuß, Rieder
2142890	Physics for Engineers (p. 285)	2	S	4	P. Gumbsch, A. Nesterov-Müller, D. Weygand, T. Förtsch
2174576	Systematic Materials Selection (p. 353)	3	S	5	S. Dietrich
2161212	Vibration Theory (p. 361)	3	W	5	A. Fidlin
0186000	Probability Theory and Statistics (p. 392)	3	S	5	D. Hug
2165512	Heat and Mass Transfer (p. 389)	2	W	4	U. Maas
2181738	Scientific computing for Engineers (p. 397)	2	W	4	D. Weygand, P. Gumbsch

Learning Control / Examinations
2 individual exams: written or oral, graded

Conditions
See Studienplan

Learning Outcomes
The course “Grundlagen und Methoden des Theoretischen Maschinenbaus” serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.
The specific learning outcomes are defined by the respective coordinator of the course.

Content
see chosen course

Remarks
none

Module: Fundamentals and Methods of Materials and Structures for High Performance Systems [MSc-Modul W+S, WPF W+S]

Coordination: M. Heilmaier
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration
8		

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2174576	Systematic Materials Selection (p. 353)	3	S	5	S. Dietrich
2147175	CAE-Workshop (p. 96)	3	W/S	4	A. Albers, Assistenten
2162235	Introduction into the multi-body dynamics (p. 119)	3	S	5	W. Seemann
2117095	Basics of Technical Logistics (p. 178)	4	W	6	M. Mittwollen, J. Oellerich
2161224	Machine Dynamics (p. 223)	3	S	5	C. Proppe
2161254	Mathematical Methods in Strength of Materials (p. 230)	3	W	5	T. Böhlke
2162280	Mathematical Methods in Structural Mechanics (p. 234)	3	S	5	T. Böhlke
2183702	Modelling of Microstructures (p. 254)	3	W	5	A. August, B. Nestler, D. Weygand
2183703	Numerical methods and simulation techniques (p. 258)	3	W/S	5	B. Nestler
4040311	Modern Physics for Engineers (p. 261)	2	S	5	B. Pilawa
2142890	Physics for Engineers (p. 285)	2	S	4	P. Gumbsch, A. Nesterov-Müller, D. Weygand, T. Förtsch
2181612	Physical basics of laser technology (p. 287)	3	W	4	J. Schneider
2161212	Vibration Theory (p. 361)	3	W	5	A. Fidlin
2181738	Scientific computing for Engineers (p. 397)	2	W	4	D. Weygand, P. Gumbsch

Learning Control / Examinations
2 individual exams: written or oral, graded

Conditions
See Studienplan

Learning Outcomes
The course “Grundlagen und Methoden der Werkstoffe und Strukturen für Hochleistungssysteme” serves as a comprehensive, in-depth analysis of fundamentals in selected areas of mechanical engineering.
The specific learning outcomes are defined by the respective coordinator of the course.

Content
see chosen course

Remarks
none

4 Courses

4.1 All Courses

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

Coordinators: M. Gohl, H. Kubach
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Letter of attendance or oral exam (25 minutes, no auxillary means)

Conditions
none

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

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

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

Media
Lecture with Powerpoint slides

Literature
The lecture documents are distributed during the courses.

Course: Aerodynamics [2154420]

Coordinators: F. Ohle, B. Frohnapfel
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral, 30 min,
auxiliary means: none

Conditions
none

Recommendations
Grundlagen der Strömungsmechanik, Mathematische Methoden der Strömungsmechanik

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

Content

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

Literature
J.D. Anderson, jr.. Fundamentals of Aerodynamics, McGraw-Hill
E.L. Houghton. Aerodynamics for Engineering Students, Butterworth-Heinemann (Elsevier)
Schlichting, Gersten. Grenzschichttheorie, Springer

Remarks
Block course with limited number of participants, registration in the secretary's office required.
See details at www.istm.kit.edu.

Course: Aerothermodynamics [2154436]

Coordinators: F. Seiler, B. Frohnapfel
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
none

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

Content

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

Literature
H. Oertel jun.: Aerothermodynamik, Springer-Verlag, Berlin Heidelberg New York, 1994
F. Seiler: Skript zur Vorlesung über Aerothermodynamik

Remarks
Block course with limited number of participants, registration in the secretary's office required. See details at www.istm.kit.edu

Course: Actuators and sensors in nanotechnology [2141866]

Coordinators: M. Kohl
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
as elective subject in major field or as optional subject, oral exam, 30 minutes

Conditions
None.

Recommendations
The lecture addresses students in the fields of mechanical engineering, mechatronics and information technology, materials science and engineering, physics, electrical engineering and economic sciences. A comprehensive introduction is given in the basics and current developments on the nanoscopic length scale.

Learning Outcomes
- Knowledge of the principles of actuation and sensing
- Knowledge of important fabrication technologies
- Explanation of typical properties (time constants, sensitivities, forces, etc.)
- Explanation of layout and function of the actuators and sensors

Content
- Physical principles of actuation and sensing
- Scaling and size effects
- Fabrication technologies
- Selected developments
- Applications

The lecture includes amongst others the following topics:
Nano technologies
Nano electro mechanical systems (NEMS)
Nano magneto mechanical and multiferroic systems
Polymer-based nano actuators
Nano motors, molecular systems
Adaptive nano optical systems
Nanosensors: concepts, materials, fabrication
Examples on different categories of materials and applications:
C-based, MeOx-based nano sensors
Physical, chemical, biological nano sensors
Multivariant data analysis / interpretation

Literature
- Lecture notes
- 2. Balzani, V., Credi, A., & Venturi, M., Molecular devices and machines: concepts and perspectives for the nanoworld, 2008
- „Nanowires and Nanobelts, - Materials, Properties and Devices -, Volume 2: Nanowires and Nanobelts of Functional Materials“, Edited by Zhong Lin Wang, Springer, 2003, ISBN 10 0-387-28706-X
- „Sensors Based on Nanostructured Materials“, Edited by Francisco J. Arregui, Springer, 2009, ISBN: 978-0-387-77752-8
- “Multivariate Datenanalyse – Methodik und Anwendungen in der Chemie”, R. Henrion, G. Henrion, Springer 1994, ISBN 3-540-58188-X

Course: Applied Tribology in Industrial Product Development [2145181]

Coordinators: A. Albers, B. Lorentz
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The goal of the lecture is to discuss tribological problems, tribological features and the tribological variety on examples of the automobile industry.
The students are able to ...

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

Content
Friction, Wear, Wear Measurement
Lubricant (Oil, Grease, etc.)
Hydrodynamic and elastohydrodynamic Lubrication
Design of Tribologic Working Surface Pairs
Technique of Measurement in Lubricated Contacts
Prevention of Maschine Failure
Protective Surface Layers
Journal Bearings, Roller Bearings
Gear Wheels and Transmissions

Literature
The lecture script will be allocated at Ilias.

Course: Applied Materials Modelling [2182614]

Coordinators: K. Schulz, P. Gumbsch
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam ca. 35 minutes
no tools or reference materials

Conditions
admission to the exam only with successful completion of the exercises

Recommendations
preliminary knowlegde in mathematics, physics and materials science

Learning Outcomes
The student can

- define different numerical methods and distinguish their range of application
- approach issues by applying the finite element method and discuss the processes and results
- understand complex processes of metal forming and crash simulation and discuss the structural and material behavior
- define and apply the physical fundamentals of particle-based simulation techniques to applications of materials science
- illustrate the range of application of atomistic simulation methods and distinguish between different models

Content
This lecture should give the students an overview of different simulation methods in the field of materials science and engineering. Numerical methods are presented and their use in different fields of application and size scales shown and discussed. On the basis of theoretical as well as practical aspects, a critical examination of the opportunities and challenges of numerical material simulation shall be carried out.

Media
black board, beamer, script, computer exercise

Literature

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

Course: Drive Train of Mobile Machines [2113077]

Coordinators: M. Geimer, M. Scherer, D. Engelmann
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The final assessment will be an oral examination taking place during the recess period. The examination will be offered in every semester and can be repeated at any regular examination date.

Conditions
None.

Recommendations

- General principles of mechanical engineering
- Basic knowledge of hydraulics
- Interest in mobile machinery

Learning Outcomes
At the end of the lecture, participants can explain the structure and function of all discussed drive trains of mobile machines. They can analyze complex gearbox schematics and synthesize simple transmission functions using rough calculations.

Content
In this course the different drive trains of mobile machinery will be discussed. The focus of this course is:
- mechanical gears
- torque converter
- hydrostatic drives
- power split drives
- eletrical drives
- hybrid drives
- axles
- terra mechanics

Media
projector presentation

Literature
Download of lecture slides from ILIAS. Further literature recommendations during lectures.

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

Coordinators: D. Weygand
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam ca. 30 minutes

Conditions
The lecture can not be combined with the course "Scientific Programming for Engineers" (2181738).

Learning Outcomes
The student can

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

Through the accompanying exercises the students are able to apply the content of the lecture.

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

* Fortran 95/2003
- structure of source code
- progamming
- compiling
- debugging
- parallelization with OpenMP
* numerical methods
* script languages: Python, awk
* visualisation
Exercises (2182736, 2 SWS) are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students and for testing progress in learning of the topics.

Literature

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

Course: Human Factors Engineering I: Ergonomics [2109035]

Coordinators: B. Deml

Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
written exam
The exams are only offered in German!

Conditions
None

Learning Outcomes
The students acquire a basic knowledge in the field of ergonomics:

- They are able to consider cognitive, physiological, anthropometric, and safety technical aspects in order to design workplaces ergonomically.
- Just as well they know physical and psycho-physical fundamentals (e. g. noise, lighting, climate) in the field of work-environmental design.
- Furthermore the students are able to evaluate workplaces by knowing and being able to apply essential methods of time studies and payment systems.
- Finally, they get a first, overall insight into the German labour law as well as into the organisation of advocacy groups beyond companies.

Further on the participants get to know basic methods of behavioral-science data acquisition (e. g. eye-tracking, ECG, dual-task-paradigm).

Content

1. Principles of human work
2. Behavioural-science data acquisition
3. workplace design
4. work environment design
5. work management
6. labour law and advocay groups

Literature
The lecture material is available on ILIAS for download.

Course: Human Factors Engineering II: Work Organisation [2109036]

Coordinators: B. Deml
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Compulsory Elective Module Economics/Law (p. 45)[MSc-Modul 12, WF WR]

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

Learning Control / Examinations
written exam
The exams are only offered in German!

Conditions
None.

Learning Outcomes
The students gain a first insight into empirical research methods (e. g. experimental design, statistical data evaluation). Particularly, they acquire a basic knowledge in the field of work organisation:

- *Organizational level*. Within this module the students gain also a fundamental knowledge in the field of structural, process, and production organization.
- *Group level*. Besides, they get to know basic aspects of industrial teamwork and they know relevant theories in the field of interaction and communication, the management of employees as well as work satisfaction and motivation.
- *individual level*. Finally, the students get to know also methods in the field of personnel selection, development, and assessment.

Content

1. Fundamentals of work organization
2. Empirical research methods
3. Individual level
   - personnel selection
   - personnel development
   - personnel assessment
   - work satisfaction/motivation
4. Group level
   - interaction and communication
   - management of employees
   - team work
5. Organizational level
   - structural organization
   - process organization
   - production organization

Literature
The lecture material is available on ILIAS for download.

Course: Atomistic simulations and molecular dynamics [2181740]

Coordinators: C. Brandl, P. Gumbsch
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
oral exam ca. 30 minutes

Conditions
compulsory preconditions: none

Recommendations
preliminary knowlegde in mathematics, physics and materials science

Learning Outcomes
The student can

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

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

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

Exercises (2181741, 2 SWS) are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students.

Literature

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

Course: Constitution and Properties of Wear resistant materials [2194643]

Coordinators: S. Ulrich
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination (30 min)

no tools or reference materials

Conditions
None

Recommendations
None

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

Content
introduction

materials and wear

unalloyed and alloyed tool steels

high speed steels

stellites and hard alloys

hard materials

hard metals

ceramic tool materials

superhard materials

new developments

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

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

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

Copies with figures and tables will be distributed

Course: Constitution and Properties of Protective Coatings [2177601]

Coordinators: S. Ulrich
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination (30 min)

no tools or reference materials

Conditions
None

Recommendations
None

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

Content
introduction and overview

concepts of surface modification

coating concepts

coating materials

methods of surface modification

coating methods

characterization methods

state of the art of industrial coating of tools and components

new developments of coating technology

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

Copies with figures and tables will be distributed

Course: Selected Applications of Technical Logistics [2118087]

Coordinators: M. Mittwollen, V. Milushev
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
after each lesson period; oral / written (if necessary)

Conditions
none

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

Learning Outcomes
Students are able to:

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

Content
design and dimension of machines from intralogistics // static and dynamic behaviour // operation properties and specifics // visit of real intralogistic system
Inside practical lectures: sample applications and calculations in addition to the lectures

Media
supplementary sheets,projector, blackboard

Literature
Recommendations during lessons

Course: Selected Topics on Optics and Microoptics for Mechanical Engineers [2143892]

Coordinators: T. Mappes
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam, 20 min

Conditions
None.

Learning Outcomes

Content

Course: Selected chapters of the combustion fundamentals [2167541]

Coordinators: U. Maas
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral
Duration: 30 min

Conditions
None

Recommendations
None

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

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

Media
Blackboard and Powerpoint presentation

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

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

Coordinators: R. Dagan
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam, 30 min.

Conditions
none

Recommendations
none

Learning Outcomes
The students

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

Content

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

Literature
K. Wirtz Basics of Reactor technic Par I, II, Technic School Karlsruhe 1966 (in German)
D. Emendorfer. K.H. Höcker Theory of nuclear reactions, BI- Hochschultaschenbücher 1969 (in German)
J. Duderstadt and L. Hamilton, Nuclear reactor Analysis, J. Wiley $ Sons, Inc. 1975.

Course: Virtual Engineering (Specific Topics) [3122031]

Coordinators: J. Ovtcharova
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination
Duration: 20 min

Auxiliary Means: none

Conditions
None

Recommendations
None

Learning Outcomes
The students will acquire an introduction in Product Lifecycle Management (PLM) and understand the application of PLM in Virtual Engineering.
Furthermore, they will have an extensive knowledge of the data models, the specific modules and functions of CAD systems. They will have an awareness of the IT background of CAx systems, as well as the integration problems and possible approaches.
Students will receive an overview of various CAE analysis methods along with the application possibilities, basic conditions and limitations. They will know the different function of preprocessor, solver and postprocessor of CAE systems.
The students will get to know the definition of virtual reality how the stereoscopic effect occurs and which technologies can be used to simulate this effect.
Moreover, they will know which validation tests can be carried through in the product development process with the aid of a virtual mock-up (VMU) and what's the difference between a VMU, a physical mock-up (PMU) and a virtual prototype (VP).

Content
The lecture presents the informational interrelationship required for understanding the virtual product development process. For this purpose, an emphasis and focus will be placed on IT-systems used in the industrial sector as support for the process chain of virtual engineering:

- Product Lifecycle Management refers to the entire lifecycle of the product, beginning with the concept phase up through disassembling and recycling.
- CAx-systems for the virtual product development allow the modeling of a digital product in regards to design, construction, manufacturing and maintenance.
- Validation Systems allow the checking of the product in regard to static, dynamics, safety and build ability.
- The corresponding models can be visualized in Virtual Reality Systems, from single parts up through a complete assembly.
- Virtual Prototypes combine CAD-data as well as information about the remaining characteristics of the components and assembly groups for immersive visualisation, functionality tests and functional validations in the VR/AR/MR environment.
- Integrated Virtual Product Development explains exemplified the product development process from the point of view of Virtual Engineering.

The goal of the lecture is to clarify the relationship between construction and validation operations through the usage of virtual prototypes and VR/AR/MR visualisation techniques in connection with PDM/PLM-systems.

Literature
Lecture slides

Course: Design of highly stresses components [2181745]

Coordinators: J. Aktaa
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam: 30 minutes

Conditions
material science
solid mechanics II

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

Content
Contents of the lecture:

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

Literature

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

Course: Design and Development of Mobile Machines [2113079]

Coordinators: M. Geimer, J. Siebert
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.
Required for the participation in the examination is the preparation of a report during the semester.

Conditions
The number of participants is limited. A registration is mandatory, the details will be announced on the webpages of the *Institute of Vehicle System Technology / Institute of Mobile Machines*. In case of too many applications, attendance will be granted based on pre-qualification.

Recommendations
Knowledge in Fluid Power Systems (WiSe, LV 2114093)

Learning Outcomes
After completion of the lecture, studens can:

- design working and travel drive train hydraulics of mobile machines and can derive characteristic key factors.
- choose and apply suitable state of the art designing methods succesfully
- analyse a mobile machine and break its structure down from a complex system to subsystems with reduced complexity
- identify and describe interactions and links between subsystems of a mobile machine
- present and document solutions of a technical problem according to R&D standards

Content
The working scenario of a mobile machine depends strongly on the machine itself. Highly specialised machines, e.g. pavers are also as common as universal machines with a wide range of applications, e.g. hydraulic excavators. In general, all mobile machines are required to do their intended work in an optimal way and satisfy various critera at the same time. This makes designing mobile machines to a great and interesting challenge. Nevertheless, usually key factors can be derived for every mobile machine, which affect all other machine parameters. During this lecture, those key factors and designing mobile machines accordingly will be adressed. To do so, an exemplary mobile machine will be discussed and designed in the lecture an as a semester project.

Literature
See german recommendations.

Remarks
The course will be replenished by interesting lectures of professionals from leading hydraulic companies.

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

Coordinators: H. Faust
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral Examination

Conditions
none

Learning Outcomes
The students gain the knowledge about ...

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

Content

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

Course: Automation Systems [2106005]

Coordinators: M. Kaufmann
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam

Conditions
None.

Recommendations
Fundamentals of measuring and control engineering

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

Content

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

Literature

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

Course: Rail System Technology [2115919]

Coordinators: P. Gratzfeld
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes
The students understand relations and interdependencies between rail vehicles, infrastructure and operation in a rail system.
Based on operating requirements and legal framework they derive the requirements concerning a capable infrastructure and suitable concepts of rail vehicles.
They recognize the impact of alignment, understand the important function of the wheel-rail-contact and estimate the impact of driving dynamics on the operating program.
They evaluate the impact of operating concepts on safety and capacity of a rail system.

Content

1. Railway System: railway as system, subsystems and interdependencies, definitions, laws, rules, railway and environment, economic impact
2. Operation: Transportation, public transport, regional transport, long-distance transport, freight service, scheduling
3. Infrastructure: rail facilities, track alignment, railway stations, clearance diagram
4. Wheel-rail-contact: carrying of vehicle mass, adhesion, wheel guidance, current return
5. Vehicle dynamics: tractive and brake effort, driving resistance, inertial force, load cycles
6. Signalling and Control: operating procedure, succession of trains, European Train Control System, blocking period, automatic train control
7. Traction power supply: power supply of rail vehicles, power networks, filling stations
8. History (optional)

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

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

Remarks
none

Course: Basics of Liberalised Energy Markets [2581998]

Coordinators: W. Fichtner
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

ECTS Credits	Hours per week	Term	Instruction language
3	2/1	Winter term	en

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

Conditions
None.

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

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

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

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

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

Remarks
The course “Basics of Liberalised Energy Markets” [2581998] will be reduced to 3 credits in winter term 2015/2016 and the tutorial [2581999] is no longer offered.

Course: Fuels and Lubricants for Combustion Engines [2133108]

Coordinators: B. Kehrwald, H. Kubach
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination, Duration: ca. 25 min., no auxiliary means, exam dates directly after lecture period

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can name and explain composition and meaning of fuels, lubricants and coolants as important components in the system of todays Otto and Diesel engines as well as definition and chemical composition of fuels and lubricants, the meanig of crude oil as basic primary product, production processes, major properties, standards and specifications, testing methods.
They can point out future worldwide trends in the field of conventional and alternative fuels regarding emission standards and energy conservation

Content
Introduction and basics

Fuels for Gasoline and Diesel engines

Hydrogen

Lubricants for Gasoline and Diesel engines

Coolants for combustion engines

Media
script, will be provided in the lecture

Literature
Lecturer notes

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

Coordinators: A. Guber
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The examination is in the form of a written examination (90 min.) (according to §4(2), 1 SPO).

Conditions
None.

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

Content
Introduction into various microtechnical manufacturing methods: LIGA, Micro milling, Silicon Micromachining, Laser Microstructuring, µEDM, Metal-Etching
Biomaterials, Sterilisation, Implants.
Examples of use in the life science sector: basic micro fluidic strucutures: micro channels, micro filters, micromixers, micropumps, microvalves, Micro and nanotiter plates, Microanalysis systems (µTAS),
Lab-on-chip applications.

Media
Lecture script

Literature
Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005
M. Madou
Fundamentals of Microfabrication
Taylor & Francis Ltd.; Auflage: 3. Auflage. 2011

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

Coordinators: A. Guber
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination

Conditions
None.

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

Content
Examples of use in Life-Sciences and biomedicine: Microfluidic Systems:
LabCD, Digital Micro Fluidics
Microarrys
Tissue Engineering
Cell Chip Systems
Drug Delivery Systems
Microsystem Technology for Anesthesia, Intensive Care and Infusion
Analysis Systems of Person´s Breath
Neurobionics and Neuroprosthesis
Nano Surgery

Media
Lecture script

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

Buess, G.: Operationslehre in der endoskopischen Chirurgie, Band I und II;
Springer-Verlag, 1994
M. Madou
Fundamentals of Microfabrication (2011)

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

Coordinators: A. Guber
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Learning Outcomes
The lecture will address selected biomedical applications, as the increasing use of microstructures and microsystems in Life-Sciences und in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

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

Media
Lecture script

Literature
Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005
Buess, G.: Operationslehre in der endoskopischen Chirurgie, Band I und II;
Springer-Verlag, 1994
M. Madou
Fundamentals of Microfabrication (2011)

Course: [2141102]

Coordinators: A. Guber
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Learning Outcomes

Content

Course: Bionics for Engineers and Natural Scientists [2142140]

Coordinators: H. Hölscher
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The successfull attandence of the lecture is controlled by a 90 minutes written examination outside of term-time once per semester.

Conditions
none

Learning Outcomes

Content

Literature
Werner Nachtigall: Bionik – Grundlagen und Beispiele für Ingenieure und Naturwissenschaftler. Springer-Verlag Berlin (2002), 2. Aufl.
Weitere Originalliteratur wird über ILIAS zur Verfügung gestellt.

Course: BUS-Controls [2114092]

Coordinators: M. Geimer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.
The prerequisite for participation in the examination is the preparation of a report.

Conditions
None.

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

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

After the practical oriented lessons the students will be able to visualize the communication structure of different applications, design basic systems and evaluate the complexity of programming of the complete system.
Hereunto the students program in the practical orientated lessons IFM-controllers using the programming environment CoDeSys.

Content

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

Literature
Elective literature:

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

Remarks
The number of participants is limited. A registration is mandatory, the details are announced on the webpages of the *Institute of Vehicle System Technology | Institute of Mobile Machines*. In case of too many interested students a subset will be selected based on pre-qualification.

Course: CAE-Workshop [2147175]

Coordinators: A. Albers, Assistenten

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

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

Learning Control / Examinations
Written-practical exam, duration 60 min

Conditions
compulsory attendance

Recommendations
We suggest this Workshop after 2 years of classes.

Learning Outcomes
The students are able to ...

- name the purposes and limits of numerical simulation and optimization of the virtual product development.
- solve simple realistic tasks in the field of finite element analysis and structure optimization with industrial common software.
- evaluate and to question the results of a simulation.
- identify and improve the mistakes of a simulation or optimization.

Content

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

Literature
The workshop script will be allocated at Ilias.

Course: CFD for Power Engineering [2130910]

Coordinators: I. Otic
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam, length: 30 minutes

Conditions
None.

Learning Outcomes
After completing the course students are able:

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

Content
The course is aimed of giving the fundamental of Computational Fluid Dynamics (CFD) for energy technologies. Starting from the basic physical phenomena equations an overview on computational methods and turbulence modeling is given.
The course consists of both, a theoretical and a numerical component. The former will deal with the derivations and properties of the methods and models for CFD. The numerical part will make use of open source CFD computer program OpenFOAM to give a “hands on” insight into the simulation of turbulent flows. After completing the course you should be able to establish a connection between theory and CFD modeling and simulation for energy applications.

Course: Chemical Fuels [22331]

Coordinators: S. Bajohr, G. Schaub
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
The examination results from the chosen module, otherwise:
oral examination
Duration: 30 min

Conditions
None

Recommendations
None

Learning Outcomes
After completing the course students can:

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

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

Media
Blackboard and slides/power point presentation

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

Course: Coal fired power plants [2169461]

Coordinators: T. Schulenberg
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Knowledge in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in power plant engineering. The participants can name the most important components of coal fired power plants and describe their function. They can design or modify coal fired power plants independently and creatively. They have acquired a broad knowledge of this power plant technology, including specific knowledge of combustion systems, of boiler design and of flue gas cleaning systems. On this basis, they can describe and analyze the specific behavior of the power plant components as well as the entire power plant in the grid. Participants in the lecture have a trained analytical thinking and judgment in power plant design.

Content
The lecture presents the technology of coal fired power plants, which are conventional steam turbine plants as well as advanced combined cycle power plants with integrated coal gasification. It includes combustion systems, steam generators, a short overview over steam turbine technologies, the cooling system and the water supply system as well as the off gas treatment. Coal gasification will be explained with fixed bed, fluidized bed and entrained flow gasifiers. The integrated coal gasification combined cycle includes also the raw gas purification system. In addition, a visit to a coal fired power plant will be offered.

Media
power point presentation for download from the ILIAS server

Literature
Lecture notes (Vorlesungsskript) for download from the ILIAS Server
Everett B. Woodruff, Herbert B. Lammers, Thomas F. Lammers, Steam Plant Operation, 9th Edition, McGraw Hill, New York 2012

Course: Computational Intelligence [2105016]

Coordinators: R. Mikut, W. Jakob, M. Reischl
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination or written examination (for more than 40 participants),
Duration: 30min (oral) or 60 min (written)
Auxilary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students are able to apply the fundamental methods of computational intelligence (fuzzy logic, artificial neural networks, evolutionary algorithms) efficiently. They know the basic mathematical foundations and are able to transfer these methods to practical applications.

Content

- Terms and definitions Computational Intelligence, application fields and examples
- Fuzzy logic: fuzzy sets; fuzzification and membership functions; inference: T-norms and -conorms, operators, aggregation, activation, accumulation; defuzzification methods, structures for fuzzy control
- Artificial Neural Nets: biology of neurons, Multi-Layer-Perceptrons, Radial-Basis-Function nets, Kohonen maps, training strategies (Backpropagation, Levenberg-Marquardt)
- Evolutionary Algorithms: Basic algorithm, Genetic Algorithms and Evolution Strategies, Evolutionary Algorithm GLEAM, integration of local search strategies, memetic algorithms, application examples

Literature
Lecture notes (ILIAS)
Kiendl, H.: Fuzzy Control. Methodenorientiert. Oldenbourg-Verlag, München, 1997
S. Haykin: Neural Networks: A Comprehensive Foundation. Prentice Hall, 1999
Kroll, A. Computational Intelligence: Eine Einführung in Probleme, Methoden und technische Anwendungen Oldenbourg Verlag, 2013
Blume, C, Jakob, W: GLEAM - General Learning Evolutionary Algorithm and Method: ein Evolutionärer Algorithmus und seine Anwendungen. KIT Scientific Publishing, 2009 (PDF frei im Internet)
H.-P. Schwefel: Evolution and Optimum Seeking. New York: John Wiley, 1995
Mikut, R.: Data Mining in der Medizin und Medizintechnik. Universitätsverlag Karlsruhe; 2008 (PDF frei im Internet)

Course: Engineer's Field of Work [2114917]

Coordinators: P. Gratzfeld, M. Doppelbauer
Part of the modules: Key Qualifications (p. 46)[MSc-Modul, SQL]

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

Learning Control / Examinations
Colloquium
Duration: 20 minutes
result: passed / not passed
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes

- The students know the characteristics of an industriell working environment.
- They understand the effectiveness of typical structures in companies and the intention of the most relevant business processes.
- They can judge the impact of regulatory framework on their daily work.

Content

1. **Organization of Companies**
organizational structure, organizational units, managerial structure, organization charts, project organization, relation between superior and staff, board of managing directors, management of the company, supervisory board, advisory board
2. **Project Management**
definition of project, project manager, project team, primary processes, supporting processes
3. **Personnel Development**
applications, trainee programs, management career, professional career, career paths in companies, individual career planning, tasks of HR, manpower requirements planning, training, training-on-the-job, tools for human resource management, annual personnel talk, objective agreement
4. **Scheduling**
Methods for detailed scheduling, network plans, critical path, Gantt-diagram, milestones
5. **Development Processes**
research, advance development, series development, product marketing, V-model, SPALTEN-model, technical specifications, requirement specifications, clarification, concept, draft, elaboration, validation, verification, documentation, FMEA
6. **Standards and Laws**
importance of standards, German and international standardization systems, committees, certification
7. **Commercial Law**
health protection, safety at work, environment protection, product liability, patents
8. **Calculation, Financial Statement**
contract award estimate, project costing, unit cost, target costs, cost center accounting, cost recording, hourly rates, asset accounting, profit and loss statement

9. **Governance**
   principles of governance (accountability, responsibility, transparency, fairness), leadership (technical, commercial), reviews, boards, audits, codetermination, compliance

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

Remarks
The lecture is mandatory for Master Mechatronics and Information Technology.
It is also very well suited as key qualification for all other master programs in engineering.

Course: Data Analytics for Engineers [2106014]

Coordinators: R. Mikut, M. Reischl, J. Stegmaier
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination or written examination (for more than 40 participants),
Duration: 30min (oral) or 60 min (written)
Auxilary means: none

Conditions
None.

Recommendations
None.

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

Content

- Introduction and motivation
- Terms and definitions (types of multidimensional features - time series and images, problem classes)
- Scenario: Problem formulation, feature extraction, evaluation, selection and transformation, distance measures, Bayes classifiers, Support-Vector-Machines, decision trees, clustering, regression, validation
- Biweekly computer exercises (Software practice with SciXMiner): Data import, benchmark datasets, control of hand prostheses, energy prediction
- 2 hours per week lectures, 1 hour per week computer training

Literature
Lecture notes (ILIAS)
Mikut, R.: Data Mining in der Medizin und Medizintechnik. Universitätsverlag Karlsruhe. 2008 (free PDF in the Internet)
Backhaus, K.; Erichson, B.; Plinke, W.; Weiber, R.: Multivariate Analysemethoden: Eine anwendungsorientierte Einführung. Berlin u.a.: Springer. 2000
Burges, C.: A Tutorial on Support Vector Machines for Pattern Recognition. Knowledge Discovery and Data Mining 2(2) (1998), S. 121–167
Tatsuoka, M. M.: Multivariate Analysis. Macmillan. 1988
Mikut, R.; Bartschat, A.; Doneit, W.; Ordiano, J. Á. G.; Schott, B.; Stegmaier, J.; Waczowicz, S. & Reischl, M.: The MATLAB Toolbox SciXMiner: User's Manual and Programmer's Guide. arXiv:1704.03298, 2017

Course: A holistic approach to power plant management [2189404]

Coordinators: M. Seidl, R. Stieglitz
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
oral

Conditions
none

Learning Outcomes
Students understand the many aspects of power plant operation: the structure of the energy and commodity markets, the regulatory boundary conditions, the energy trading instruments, the principles of fleet management and the requirements of power plant maintenance.
Furthermore, students can develop on their own a suitable strategy for the management of a power plant fleet.

Content
Industrial scale power plants are significant investments and their safe and economical operation requires careful examination of risk and uncertainty. Risk factors are, for example, technology, energy and commodity markets, regulatory boundary conditions and socioeconomic trends. They all require a disciplined fleet management to maximize asset value.
Risk and uncertainty factors are explained in depth as are the two fundamental vehicles for risk modelling: stochastic processes for random patterns and machine learning for repetitive patterns. They are combined to determine the optimal policy for decision making in the day-to-day management of power plants.

Literature
G. Balzer, C. Schorn, Asset Management für Infrastrukturanlagen - Energie und Wasser, VDI
R. Weron, Modeling and Forecasting Electricity Loads and Prices: A Statistical Approach, Wiley
D. Edwards, Energy Trading and Investing: Trading, Risk Management and Structuring Deals in the Energy Market, McGraw-Hill

Course: Value stream within enterprises – The value chain at Bosch [2149661]

Coordinators: J. Fleischer, Dr. Rudolf Maier
Part of the modules: Key Qualifications (p. 46)[MSc-Modul, SQL]

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

Learning Control / Examinations
compulsory attendance, active participation

Conditions
none

Learning Outcomes
The students . . .

- are able to deduce, understand and assess the structure of a global operating enterprise.
- are capable to identify and compare the work flows and processes within a global operating enterprise.
- are able to recognize and assess the problems within interfaces between functional and organizational units which are identified by the experts. Furthermore the students can develop solutions based on this knowledge in order to overcome these problems.

Content
The seminar provides an insight into the main functional units of a company and their typical processes by using Bosch as an example. Furthermore it is based on discussions with the students. Former Bosch top managers explain the essential business processes and functions of the individual departments as well as the classic tasks of an engineer in a worldwide operating automotive supplier. The seminar also provides an insight into the careers of the Bosch directors. In addition to the company processes, the seminar will therefore focus on reports of challenges, successes, failures and product and process innovations.

The topics are as follows:

- Introduction, strategy, innovation
- R&D, product development process
- Production
- Quality management
- Market, marketing, sales
- Aftermarket, service
- Finance, controlling
- Logistics
- Purchasing, supply chain
- IT
- HR, leadership, compliance

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
Registration required

Course: Decentrally controlled intralogistic systems [2117084]

Coordinators: K. Furmans, M. Hochstein, K. Markert
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
Certificate by colloquium with presentation

Conditions
presence obligatory

Recommendations
none

Learning Outcomes
Students are able to:

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

Content

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

Presentation of the results

Media
Lego Mindstorms, PC

Literature
none

Remarks
number of participants limited
participants will be selected
One course during summer semester in english

Course: Railways in the Transportation Market [2114914]

Coordinators: P. Gratzfeld
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes
The students realise the entrepreneurial perspective of transportation companies and are able to follow their operational fields. They understand the regulative determinates and learn to assess the intra- and intermodal competitive position.

Content
The lecture communicates the entrepreneurial view on chances and challenges of railways in the transportation markets. Following items will be discussed:

- Introduction and basics
- Rail reform in Germany
- Overview of Deutsche Bahn
- Financing and Development of infrastructure
- Regulation of railways
- Intra- and intermodal competition
- Field of actions in transport policy
- Railways and environment
- Trends in the transportation market
- Future of Deutsche Bahn, program called “Zukunft Bahn”
- Digitalisation

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

Literature
none

Remarks
For the dates please see special announcement on the website www.bahnsystemtechnik.de

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

Coordinators: C. Günther
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Duration: 30 minutes
no auxiliary means

Conditions
None.

Learning Outcomes
The students can apply the most important difference schemes for the numerical solution of steady and transient problems which are typical for thermal and fluid flow problems. They are able to discuss the most relevant properties of difference schemes such as consistency, stability and convergence. Furthermore, they can estimate the order of the numerical error and non-appearance of numerical oscillations.
The students get a basic knowledge of relevant numerical algorithms and the use of them in commercial and open fluid flow codes.

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

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

Course: Digital microstructure characterization and modeling [2162277]

Coordinators: M. Schneider
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	en

Learning Control / Examinations
oral exam

Conditions
none

Recommendations
This lecture is intended for Msc students

Learning Outcomes
The students can:
* explain the theory of homogenization for heterogeneous materials
* assess the advantages/disadvantages of different microstructure characterization methods
* write pseudocode for microstructure generation algorithms
* consider peculiarities for characterizing and modelling fiber reinforced
materials

Content
* homogenization theory of heterogeneous materials
* digital microstructure characterization
* virtual microstructure generation
* specifics for fiber reinforced composites

Literature

- Torquato, S.: Random Heterogeneous Materials. Springer, New York, 2002.
- Ohser, J. und Schladitz, K.: 3D images of Materials Structures. Wiley, Hoboken, 2009

Course: Digital Control [2137309]

Coordinators: M. Knoop
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

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

Conditions
Basic studies and preliminary examination; basic lectures in automatic control

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

Content
1. Introduction into digital control:
Motivation for digital implementation of controllers Structure of digital feedback control loops Sample and hold units
2. State space analysis and design:
Discretisation of continuous-time systems Discrete-time state space equations Stability - definition and criteria State feedback design by eigenvalue assignment PI state feedback controller Luenberger observer, separation theorem Systems with dead-time Deadbeat design
3. Analysis and design based on z-transform: z-transform - definition and theorems Control loop description in the z domain
Stability criteria Root locus controller design Transfer of continuous-time controllers into discrete-time controllers

Literature

- Lunze, J.: Regelungstechnik 2 - Mehrgrößensysteme, Digitale Regelung, 8. Auflage, Springer Verlag, Berlin Heidelberg 2014
- Unbehauen, H.: Regelungstechnik, Band 2: Zustandsregelungen, digitale und nichtlineare Regelsysteme. 8. Auflage, Vieweg Verlag, Braunschweig 2000
- Föllinger, O.: Lineare Abtastsysteme. 4. Auflage, R. Oldenbourg Verlag, München Wien 1990
- Ogata, K.: Discrete-Time Control Systems. 2nd edition, Prentice-Hall, Englewood Cliffs 1994
- Ackermann, J.: Abtastregelung, Band I, Analyse und Synthese. 3. Auflage, Springer Verlag, Berlin Heidelberg 1988

Course: Designing with numerical methods in product development [2161229]

Coordinators: E. Schnack
Part of the modules: Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
Oral examination. Duration: 20 minutes.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students are able to describe in detail the different numerical methods for product development in mechanical engineering. They are aware of the fact that modern development of products in mechanical engineering generally involves a so-called multi-field approach. This means that knowledge of thermodynamics, fluid mechanics, solid-state mechanics, electronics/electrics, and magnetism is required. In addition, the students use the methods taking into account that problems in product development are not only stationary, but very often also unstationary, i.e. time-dependent. All these aspects are reflected by modern industry software.
The students can name and describe basic methods used in modern industry software. On this basis, students can name and describe the necessary steps of a design process with an industry software being used as an example and they can analyze influencing factors. Apart from the finite element method (FEM) and the boundary element method (BEM), they also consider structural optimization with its elements of topology and shape optimization. Structural optimization will gain importance in the future.
The lecture notes are made available via ILIAS.

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

Course: Designing with composites [2162255]

Coordinators: E. Schnack
Part of the modules: Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
Oral examination. Duration: 20 minutes.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students understand and are able to describe the structure of laminated composite materials. They consider the nonlinear effects resulting from the absorption of humidity and temperature impacts. Moreover, they take into account the intrinsic stresses and strains resulting from production.
The students develop the equations required for description. They consider the transformation properties between a single-layer and a multi-layer coordinate system as well as the geometrically nonlinear behavior of the structures. On this basis, the students derive a universal lamination theory that also takes into account nonlinear effects. This is the basis for the future development of smart composites (via piezoelectric control) for new products (e.g. in aviation and automotive industries). In parallel, students are able to develop oscillation equations for composites which is the basis for any application in mechanical engineering.
The lecture notes are made available via ILIAS.

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

Course: Do it! – Service-Learning for prospective mechanical engineers [2109039]

Coordinators: B. Deml
Part of the modules: Key Qualifications (p. 46)[MSc-Modul, SQL]

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

Learning Control / Examinations
Active and regular participation (compulsory attendance); without grading.

Conditions
Timely enrollment in ILIAS; limited number of participants.

Learning Outcomes
The aim of this course is to enable students to get to know different social living and working conditions (such as a workshop for persons with disabilities), to engage in society as prospective mechanical engineers, and in doing so to develop their personality.
The overall goal is to learn by service for people, which again is an important factor for client-oriented behavior. This kind of experience and action oriented learning by social engagement is also called "service-learning". This is supposed to encourage students' willingness to change their perspective and to achieve some level of understanding for other living and working conditions in order to enhance their social skills such as empathy, communication skills, individual initiative, and conflict management as well as to support self-organized learning.
This course is carried out in cooperation with external partners; the concept also exists at other universities *(http://www.agentur-mehrwert.de/de/hochschulen/do-it-studierendenprojekte.html).*

Content
The course combines university learning with social engagement. Students leave the well-known academic working conditions and they apply engineering skills (such as the ergonomic workplace/-process design) within a social institution.
The course will take place every two weeks with each session lasting three hours. A part of the course will not be held at KIT, but at a workshop for persons with disabilities.
1) Introductory session
Technical and generic preparation of the work assignment
2) Work assignment (3 sessions)
Getting to know the working conditions in a workshop for persons with disabilities and conducting a work analysis in small groups
3) Interim review session
Sharing about the experiences
4) Implementation phase (2 sessions)
Implementing improvement measures concerning workplace/-process design in small groups
5) Evaluation session
Evaluating and reflecting as well as transferring and integrating the new experiences in their student and working
Literature:
Course material will be provided in ILIAS.

Literature
Course material will be provided in ILIAS.

Course: Dynamics of the Automotive Drive Train [2163111]

Coordinators: A. Fidlin
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Powertrain Systems Technology A: Automotive Systems
Machine Dynamics
Vibration theory

Learning Outcomes

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

Content

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

Literature

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

Course: Introduction to the Finite Element Method [2162282]

Coordinators: T. Böhlke
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
depending on choice according to acutal version of study regulations
Additives as announced
Prerequisites are met by attestations during the associated lab course.

Conditions
None.

Recommendations
The contents of the lectures “Advanced methods in strength of materials” and “Mathematical methods in strength of materials” are a prerequisite.

Learning Outcomes
The students can

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

Content

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

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

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

Course: Introduction to Nuclear Energy [2189903]

Coordinators: X. Cheng
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations

Conditions
None.

Learning Outcomes
This lecture is dedicated to students of mechanical engineering and other engineering Bachelor or Master degree courses. Goal of the lecture is the fundamental knowledge of nuclear energy and nuclear reactors. After the lecture the students understand the principle of the usage of nuclear energy, the structure and operation of nuclear power plants and nuclear safety measures. Furthermore, the students are capable of giving technical assessment of the usage of nuclear energy with respect to its safety and sustainability.

Content

Course: Introduction to Theory of Materials [2182732]

Coordinators: M. Kamlah
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam 30 minutes

Conditions
None.

Recommendations
Engineering Mechanics; Advanced Mathematics

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

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

Literature
[1] Peter Haupt: Continuum Mechanics and Theory of Materials, Springer
[2] Lecture Notes

Course: Introduction into Mechatronics [2105011]

Coordinators: M. Reischl, M. Lorch

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

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

Learning Control / Examinations
Written examination, 120 minutes

Conditions
none

Learning Outcomes
The student knows the specific challenges in interdisciplinary collaboration within the framework of mechatronics.
He is able to explain the origin, necessity and methodic implementation of interdisciplinary collaboration, to name the main difficulties as well as the special features within the development of mechatronic products from the point of view of development methodics.
The student has fundamental knowledge of modeling mechanical, hydraulically and electrically sub-systems and about suitable optimization methods.
The student knows the difference in use of the term “system” in mechatronic and mechanical use.

Content

- Introduction
- Structure of mechatronic systems
- Sensors and actuators
- Measurement processing
- Modeling of mechatronic systems
- Control of mechatronic systems
- Information processing in mechatronics

Literature

- H. Czichos. Mechatronik. Grundlagen und Anwendungen technischer Systeme. Vieweg, 2006.
- O. Föllinger. Regelungstechnik: Einführung in die Methoden und ihre Anwendung. Hüthig, 1994.
- J. Hartung. Statistik: Lehr- und Handbuch der angewandten Statistik. Oldenbourg, 2009.
- R. Isermann. Mechatronische Systeme: Grundlagen. Springer,1999.
- W. Roddeck. Einführung in die Mechatronik. Teubner, 2012.

Course: Introduction into the multi-body dynamics [2162235]

Coordinators: W. Seemann

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
Written or oral exam.
Announcement 6 weeks prior to examination date.

Conditions
None.

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

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

Literature
Wittenburg, J.: Dynamics of Systems of Rigid Bodies, Teubner Verlag, 1977
Roberson, R. E., Schwertassek, R.: Dynamics of Multibody Systems, Springer-Verlag, 1988
de Jal'on, J. G., Bayo, E.: Kinematik and Dynamic Simulation of Multibody System.
Kane, T.: Dynamics of rigid bodies.

Course: Introducion to numerical mechanics [2161226]

Coordinators: E. Schnack
Part of the modules: Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
Oral examination. Duration: 20 minutes.

Conditions
None.

Recommendations
None.

Learning Outcomes
After having attended the course, the students can describe the numerical treatment of mechanical problems with the finite element method (FEM) based on technical mechanics. Using concrete examples (spring, rod and beam systems), students can describe the setup of finite elements. The students can name the tools of numerical mathematics relevant to the handling/use of finite elements and can describe them in their variety. Later on, the students derive the basic equation of the finite element method. Based on this detailed derivation in the course of the lecture and taking into account tools of informatics, the students develop own codes for engineering software.
The specific aim of this course is a deeper understanding of the construction of numerical methods for the students to be able to develop such a software independently. The aim is not to learn how to work with existing software, as both software and the corresponding applications develop further very quickly. The emphasis will therefore be placed on the development and discussion of basic detailed derivations by the students.
The lecture notes are made available via ILIAS.

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

Course: Introduction to Nonlinear Vibrations [2162247]

Coordinators: A. Fidlin
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
7	4	Winter term	de

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Vibration theory, mathematical methods of vibration theory, dynamic stability

Learning Outcomes
The students

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

Content

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

Literature

- Hagedorn P. Nichtlineare Schwingungen. Akademische Verlagsgesellschaft, 1978.
- Nayfeh A.H., Mook D.T. Nonlinear Oscillation. Wiley, 1979.
- Thomsen J.J. Vibration and Stability, Order and Chaos. McGraw-Hill, 1997.
- Fidlin A. Nonlinear Oscillations in Mechanical Engigeering. Springer, 2005.
- Bogoliubov N.N., Mitropolskii Y.A. Asymptotic Methods in the Theory of Nonlinear Oscillations. Gordon and Breach, 1961.
- Nayfeh A.H. Perturbation Methods. Wiley, 1973.
- Sanders J.A., Verhulst F. Averaging methods in nonlinear dynamical systems. Springer-Verlag, 1985.
- Blekhman I.I. Vibrational Mechanics. World Scientific, 2000.
- Moon F.C. Chaotic Vibrations – an Introduction for applied Scientists and Engineers. John Wiley & Sons, 1987.

Course: Electric Power Generation and Power Grid [23399]

Coordinators: B. Hoferer
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
oral examination

Conditions
none

Recommendations
none

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

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

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

Course: Electric Power Transmission & Grid Control [23376]

Coordinators: T. Leibfried
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Power Point Presentation worked out and presented by the student about special topics presented in the lecture, each student will get his own topic for presentation
Duration: 15-20 minutes plus discussion

Conditions
none

Recommendations
none

Learning Outcomes
After completing the course students

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

They understand the basic working principle oft he power grid control system.

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

Media
Blackboard and Powerpoint presentation

Literature
Course note packet
P. Kundur
"Power System Stability and Control"
McGraw-Hill Inc., 1994, ISBN 0-07-035958-X
N. G. Hingorani, L. I. Gyugyi
"Understanding FACTS"
Institute of Electrical and Electronics Engineers Inc., 2000, ISBN 0-7803-3455-8

Course: Electrical Machines [2306315]

Coordinators: M. Doppelbauer
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
oral examination;
duration: 20-30 minutes

Conditions
S. module

Recommendations
Candidates should have attended lectures and exercises.

Learning Outcomes
After completing the course the students are able to:

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

Content

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

Media
Blackboard and powerpoint presentation. Practical examples as needed.

Literature
Course note packet

- H. A. Toliyat, G. B. Kliman: **Handbook of Electric Motors,** CRC Press, Taylor&Francis Group, 2004
- T. Wildi: **Electrical Machines, Drives and Power Systems,** Prentice Hall, 2005
- J.R. Hendershot, T. Miller: **Design of Brushless Permanent-Magnet Motors,** Magna Physics Publishing and Oxford University Press, 1994
- P.L. Alger: **The Nature of Polyphase Induction Machines,** John Wiley&Sons, Inc. and Chapmann&Hall, Ltd., 1951
- Rolf Fischer: **Elektrische Maschinen** (German language only), Carl Hanser Verlag, 2009

Course: Electric Rail Vehicles [2114346]

Coordinators: P. Gratzfeld
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes
The students know the history of electric traction in railway transportation from the very beginning to modern vehicles with three-phase traction drives.
They know the basics of railway transportation, vehicle dynamics and wheel-rail-contact and can deduct the requirements for electric rail vehicles out of it.
They understand purpose, design and functionality of electric traction drives.
They learn about the different systems of traction power supply with its advantages and disadvantages.
They are informed about actual concepts and new developments in the field of electric railway vehicles.

Content
History of electric traction with railway vehicles, economic impact
Vehicle dynamics: running resistance, tractive effort diagram, running cycles
Wheel-rail-contact
Electric drives: traction motors, power conversion, drives for vehicles at dc and ac lines, dieselelectric vehicles, multi system vehicles, axle drives, transmission of tractive effort to the rails
Traction power supply: networks, substations, inductive power supply, energy management
Modern vehicle concepts for mass transit and main line

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

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

Course: Electrical Engineering II [23224]

Coordinators: W. Menesklou
Part of the modules: Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

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

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

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

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

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

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

Literature
Online material is available on http://www.iwe.kit.edu/
Elective literature:
Will be announced during the lecture.

Course: Elements of Technical Logistics [2117096]

Coordinators: M. Mittwollen, G. Fischer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
after each lesson period; oral / written (if necessary)

Conditions
None.

Recommendations
previous / parallel visit of LV 21177095 “Grundlagen der Technischen Logistik”

Learning Outcomes
Students are able to:

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

Content
material flow systems and their (conveying) technical components
mechanical behaviour of conveyors;
structure and function of conveyor machines; elements of intralogistics (belt conveyor, racks, automatic guided vehicles, fan-in, bifurcation, and etc.)
sample applications and calculations in addition to the lectures inside practical lectures

Media
supplementary sheets,projector, blackboard

Literature
recommendations during lectures

Course: Elements of Technical Logistics - Project [2117097]

Coordinators: M. Mittwollen, G. Fischer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Lesson: after each lesson period; oral / written (if necessary)
(counts two-thirds);
Project: presentation, marked (counts one third)

Conditions
None.

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

Learning Outcomes
Students are able to:

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

Content
mechanical behaviour of conveyors;
structure and function of conveyor machines; elements of intralogistics (belt conveyor, racks, automatic guided vehicles, fan-in, bifurcation, and etc.)
sample applications and calculations in addition to the lectures inside practical lectures
Self manufacturing of a project report to recesses the topic.

Media
supplementary sheets,projector, blackboard

Literature
recommendations during lectures

Course: Energy efficient intralogistic systems [2117500]

Coordinators: M. Braun, F. Schönung
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral,30 min, examination dates after the end of each lesson period

Conditions
None.

Recommendations
None.

Learning Outcomes
Students are able to:

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

Content
The main focuses of the course are:

- green supply chain
- processes in Intralogistic systems
- evaluation of energy consumption of conveyors
- modeling of conveying systems
- methods for energy savings
- approaches for energy efficiency increasing of continuous and discontinuous conveyors
- dimensioning energy efficient drives
- new approaches for resource efcient material handling equipment and systems
  - benchmarking of energy efficiency of various intralogistics systems

Media
presentations, black board

Literature
None.

Remarks

- The content of the course "Fundamentals of technical logistics" should be known
- During the course there will be several external specific presentations of energy related topics of intralogistics companies
- Visit the IFL homepage of the course for the course dates and/or possible limitations of course participation

Course: Energy Storage and Network Integration [2189487]

Coordinators: R. Stieglitz, W. Jaeger, Jäger, Noe
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral: (can be given in english)
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
The courses 2189487 Energiespeicher und Netzintegration and 23687 Energy Storage and Network Integration can not be combined.

Recommendations
Fundamentals in material sciences, fluid dynamics and chemistry
Fundamental Knowledge of energy technology, thermodynamics, physics and electrical engineering

Learning Outcomes
Students understand the different types of energy storage in a physical sense. They are enabled to evaluate their capacity and limitiations and how physical conditions translate into technical designs. Based on these fundamentals they are taught to apply the gained knowledge for the selection and principal dimensioning of relevant energy storage tasks.
Furthermore, students can reflect the state-of-the-art of most important energy storage types, their fundamental characterisitics and viability at given boundary conditions and they are enabled to elaborate and apply basic integration issues dependent on the grid structure for the different network types.

Content
The lecture provides an overview of the different storage types and their fundamental integration into the power supply grid.
Thereby, within the scope of this lecture, the necessity and the motivation for converting and storing energy will be given. Starting from the definition of fundamental terms different physical and chemical storage types along with their theoretical and practical basis are described. In particular, the decoupling of energy production and energy consumption, and the provision of different energy scales (time, power, density) will be discussed. Furthermore, the challenge of energy transport and re-integration into the different grid types is considered.
Main Contents

1. Motivation for the need of energy storage in energy systems
   (a) National and international situation
   (b) Storage motivation
2. Terms and definitions
   (a) Different energy types
   (b) Definitions energy content
   (c) Definitions energy- and power density
3. Thermal energy storage
   (a) Classification
   (b) Sensitive heat storage
   (c) Latent heat storage
   (d) Reaction heat storage
4. Mechanical energy storage

   (a) Flywheels
   (b) Compressed air
   (c) Pumpes storage systems
5. Electrodynamic energy storage
   (a) Main principles
   (b) Capazitive and inductive storage
6. Electrochemical energy storage
   (a) Working principles
   (b) Batteries
   (c) Fuel Cells
7. Network types
   (a) Integrated networks
   (b) Supply security
8. Electric Power Systems
   (a) Storage tasks
   (b) Storage íntegration
   (c) Planning reserves
9. Heat networks
   (a) Feed in and heat distribution
   (b) Planning supply
10. Transport of chemical energy carriers and networks
   (a) Capacity and safety
   (b) Options for conversion

The lecturer reserves the right to alter the contents of the course without prior notification.

Media
Päsentation (transparencies exclusivley in english) complemented by print-outs, exercise sheets

Literature
Within each subblock an adequate selection of literature is given. Additionally the students get the lecuture materials in printed and electronic version.

Course: Energy Systems I: Renewable Energy [2129901]

Coordinators: R. Dagan
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination

Conditions
None.

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

Content
The course deals with fundamental aspects of renewable energies.

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

Course: Fatigue of Welded Components and Structures [2181731]

Coordinators: M. Farajian, P. Gumbsch,
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Exercise sheets are handed out regularly.
oral examination (ca. 30 min)

no tools or reference materials

Conditions
None.

Recommendations
preliminary knowlegde materials science and mechanics

Learning Outcomes
The student can

- describe the influence of welding induced notches, defects and residual stresses on component behavior
- explain the basics of numerical and experimental methods for the evaluation of statically or cyclically loaded welds explain and can apply them
- derive measures in order to increase the lifetime of structures with welded joints under cyclical load

Content
The lecture gives an introduction to the following topics:

- weld quality
- typical damages of welded joints
- evaluation of notches, defects and residual stresses
- strength concepts: nominal, structural and notch stress concepts, fracture mechanics
- life cycle analysis
- post-treatment methods for an extented lifetime
- maintenance, reconditioning and repair

Media
Black board and slides (beamer).

Literature

1. D. Radaj, C.M. Sonsino and W. Fricke, Fatigue assessment of welded joints by local approaches, Second edition.Woodhead Publishing, Cambridge 2006.
2. FKM-Richtlinie, Bruchmechanischer Festigkeitsnachweis, Forschungskuratorium Maschinenbau, VDMA Verlag, 2009

Course: Organ support systems [2106008]

Coordinators: C. Pylatiuk
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
written examination

Conditions
None.

Recommendations
Fundamentals of medicine

Learning Outcomes
The course deals with the function and clinical application of organ support systems, artificial organs and its components.
Historical developments are displayed as well as the limitations of current systems and perspectives for future systems Finally, the limits and possibilities of transplantation and tissue engineering are given.

Content

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

Media
The slides for each lecture can be downloaded via ILIAS.

Literature

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

Course: Experimental Fluid Mechanics [2154446]

Coordinators: J. Kriegseis
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
None.

Recommendations
Fundamental Knowledge about Fluid Mechanics

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

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

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

Media
Slides, chalk board, overhead

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

Course: Metallographic Lab Class [2175590]

Coordinators: U. Hauf
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
Colloquium for every experiment, about 60 minutes, protocol

Conditions
Materials Science I/II

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

Content
Light microscope in metallography
metallographic sections of metallic materials
Investigation of the microstructure of unalloyed steels and cast iron
Microstructure development of steels with accelerated cooling from the austenite area
Investigation of microstructures of alloyed steels
Investigation of failures quantitative microstructural analysis
Microstructural investigation of technically relevant non-ferrous metals
Application of Scanning electron microscope

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

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

Literature List will be handed out with each experiment

Course: Experimental techniques in thermo- and fluid-dynamics [2190920]

Coordinators: X. Cheng
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam, duration 20 min

Conditions
none

Learning Outcomes
This lecture is for students of Mechanical Engineering and other Engineering Departments in the Bachelor program as well as in Master program. It is devoted to the fundamental processes and tasks of the experimental techniques in thermo- and fluid-dynamics. The lecture deals with the design and analysis of experimental facilities. Measurement techniques and analysis of experimental data belong also to the key issues of the lecture. This lecture will be then completed by the exercises foreseen in the KIMOF lab.

Content

1. Design and construction of experimental facilities
2. Thermo- and fluid-dynamical analysis of experimental facilities and some components
3. Measurement techniques
4. Data acquisition and data analysis
5. Application of scaling method in experimental techniques
6. Exercise in KIMOF lab

Course: Handling Characteristics of Motor Vehicles I [2113807]

Coordinators: H. Unrau
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Verbally

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

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

Content
1. Problem definition: Control loop driver - vehicle - environment (e.g. coordinate systems, modes of motion of the car body and the wheels)

2. Simulation models: Creation from motion equations (method according to D'Alembert, method according to Lagrange, programme packages for automatically producing of simulation equations), model for handling characteristics (task, motion equations)

3. Tyre behavior: Basics, dry, wet and winter-smooth roadway

Literature
1. Willumeit, H.-P.: Modelle und Modellierungsverfahren in der Fahrzeugdynamik,
B. G. Teubner Verlag, 1998

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

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

Course: Handling Characteristics of Motor Vehicles II [2114838]

Coordinators: H. Unrau
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

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

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

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

Literature
1. Zomotor, A.: Fahrwerktechnik: Fahrverhalten, Vogel Verlag, 1991
2. Mitschke, M./Wallentowitz, H.: Dynamik von Kraftfahrzeugen, Springer-Verlag, Berlin, 2004

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

Course: Vehicle Ergonomics [2110050]

Coordinators: T. Heine
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Written exam (exams are only offered in German)

Conditions
None

Learning Outcomes
An ergonomic vehicle is best adapted to the requirements, needs and characteristics of its users and thus enables effective, efficient and satisfying interaction. After attending the lecture, students are able to analyse and evaluate the ergonomic quality of various vehicle concepts and derive design recommendations. They can consider aspects of both physical and cognitive ergonomics. Students are familiar with basic ergonomic methods, theories and concepts as well as with theories of human information processing, especially theories of driver behaviour. They are capable of critically reflecting this knowledge and applying it in a flexible way within the user-centered design process.

Content

- Principles of physical ergonomics
- Principles of cognitive ergonomics
- Theories of driver behaviour
- Interface design
- Usability testing

Literature
The bibliography will be published in the lecture. The slides of the lecture are available for download on ILIAS.

Course: Vehicle Comfort and Acoustics I [2113806]

Coordinators: F. Gauterin
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture 'Vehicle Ride Comfort & Acoustics I' [2114856].

Recommendations
None.

Learning Outcomes
The students know what noises and vibrations mean, how they are generated, and how they are perceived by human beings.
They have knowledge about the requirements given by users and the public. They know which components of the vehicle are participating in which way on noise and vibration phenomenon and how they could be improved. They are ready to apply different tools and methods to analyze relations and to judge them. They are able to develop the chasis regarding driving comfort and acoustic under consideration of goal conflicts.

Content
1. Perception of noise and vibrations

3. Fundamentals of acoustics and vibrations

3. Tools and methods for measurement, computing, simulation and analysis of noise and vibrations

4. The relevance of tire and chasis for the acoustic and mechanical driving comfort:
phenomena, influencing parameters, types of construction, optimization of components and systems, conflict of goals, methods of development

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

Literature
1. Michael Möser, Technische Akustik, Springer, Berlin, 2005

2. Russel C. Hibbeler, Technische Mechanik 3, Dynamik, Pearson Studium, München, 2006

3. Manfred Mitschke, Dynamik der Kraftfahrzeuge, Band B: Schwingungen, Springer, Berlin, 1997

The script will be supplied in the lectures.

Course: Vehicle Ride Comfort & Acoustics I (eng.) [2114856]

Coordinators: F. Gauterin
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
Examination in English
Can not be combined with lecture 'Vehicle Comfort and Acoustics I' [2113806].

Recommendations
none

Learning Outcomes
The students are familiar with the basics of sound and vibration. They know how they are generated, how they are perceived by human beings, and which requirements are given by vehicle users and the society. Using the example of ride comfort, student have get to know basic approaches to reduce noise and vibration by an appropriate combination of elastic, damping, and inertial elements. They are ready to apply different tools and procedures, to do calculative and experimental analysis of dynamic vehicle systems and to interpret the results adequately.

Content
1. Perception of sound and vibration

2. Fundamentals of acoustics and vibration

3. Tools and methods for measurement, calculation, simulation, and analysis of sound and vibration

4. The relevance of tires for the acoustic and mechanical driving comfort: phenomena, influencing parameters, types of construction, optimization of components and systems, conflict of goals, methods of development

If possible, an excursion will be offered which gives insights in the development practice of a car manufacturer or a system supplier.

Literature
1. Zeller P (Ed.), Handbuch Fahrzeugakustik, Springer Vieweg, Wiesbaden 2018
2. Russel C. Hibbeler, Engineering Mechanics: Dynamics, Pearson, Munich 2017

3. Mitschke M, Wallentowitz H, Dynamik der Kraftfahrzeuge, Springer Vieweg, Wiesbaden 2014

The script will be supplied in the lectures.

Course: Vehicle Comfort and Acoustics II [2114825]

Coordinators: F. Gauterin
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture 'Vehicle Ride Comfort & Acoustics II' [2114857].

Recommendations
None.

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

Content
1. Summary of the fundamentals of acoustics and vibrations

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

Literature
The script will be supplied in the lectures.

Course: Vehicle Ride Comfort & Acoustics II (eng.) [2114857]

Coordinators: F. Gauterin
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
Examination in english
Can not be combined with lecture 'Vehicle Comfort and Acoustics II' [2114825].

Recommendations
none

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

Content
The relevance of tires, road surface, wheel imperfections, springs, dampers, brakes, bearings and bushings, suspensions, engines and drive train for the acoustic and mechanical driving comfort:
- phenomena
- influencing parameters
- types of construction
- optimization of components and systems
- target conflicts
- methods of development

Noise emission of motor vehicles
- noise stress
- sound sources and influencing parameters
- legal restraints
- optimization of components and systems
- target conflicts
- methods of development

Literature
1. Zeller P (Hrsg.), Handbuch Fahrzeugakustik, Springer Vieweg, Wiesbaden 2018
2. Russel C. Hibbeler, Engineering Mechanics: Dynamics, Pearson, Munich 2017

3. Mitschke M, Wallentowitz H, Dynamik der Kraftfahrzeuge, Springer Vieweg, Wiesbaden 2014
The script will be supplied in the lectures.

Course: Vehicle Lightweight design – Strategies, Concepts, Materials [2113102]

Coordinators: F. Henning
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
written
duration: 90 minutes
auxiliary means: none

Conditions
none

Recommendations
none

Learning Outcomes
Students learn that lightweight design is a process of realizing a demanded function by using the smallest possible mass. They understand lightweight construction as a complex optimization problem with multiple boundary conditions, involving competences from methods, materials and production.
Students learn the established lightweight strategies and ways of construction. They know the metallic materials used in lightweight construction and understand the relation between material and vehicle body.

Content
strategies in lightweight design
shape optimization, light weight materials, multi-materials and concepts for lightweight design
construction methods
differential, integral, sandwich, modular, bionic
body construction
shell, space frame, monocoque
metalic materials
steal, aluminium, magnesium, titan

Course: Vehicle Mechatronics I [2113816]

Coordinators: D. Ammon
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Written examination

Duration: 90 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

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

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

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

Course: Tires and Wheel Development for Passenger Cars [2114845]

Coordinators: G. Leister
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
None.

Recommendations
Knowledge in automotive engineering

Learning Outcomes
The students are informed about the interactions of tires, wheels and chassis. They have an overview of the processes regarding the tire and wheel development. They have knowledge of the physical relationships.

Content

1. The role of the tires and wheels in a vehicle
2. Geometrie of Wheel and tire, Package, load capacity and endurance, Book of requirement
3. Mobility strategy, Minispare, runflat systems and repair kit.
4. Project management: Costs, weight, planning, documentation
5. Tire testing and tire properties
6. Wheel technology incuding Design and manifacturing methods, Wheeltesting
7. Tire presssure: Indirect and direct measuring systems
8. Tire testing subjective and objective

Literature
Manuscript to the lecture

Course: Automotive Vision (eng.) [2138340]

Coordinators: C. Stiller, M. Lauer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	en

Learning Control / Examinations
written exam

Conditions
none

Recommendations
Fundamentals in measurement, system and control theory, e.g. from the lecture "Measurement and Control Systems". Furthermore, knowledge from the lecture "Machine Vision" is helpful, however, not mandatory.

Learning Outcomes
Machine perception and interpretation of the environment forms the basis for the generation of intelligent behavior. Especially visual perception opens the door to novel automotive applications. Driver assistance systems already improve safety, comfort and efficiency in vehicles. Yet, several decades of research will be required to achieve an automated behavior with a performance equivalent to a human operator. The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Machine vision and advanced information processing techniques are presented to provide a broad overview on seeing vehicles. Application examples from cutting-edge and future driver assistance systems illustrate the discussed subjects. The lecture consists out of 2 hours/week of lecture and 1 hour/week of computer exercises. In the computer exercises methods introduced in the lecture will be implemented in MATLAB and tested experimentally.

Content
1. Basics of machine vision
2. Binocular vision
3. Feature point methods
4. Optical flow
5. Object tracking and motion estimation
6. Self-localization and mapping
7. Road recognition
8. Behavior recognition

Literature
The slides of the lecture will be provided as pdf files. Further references will be announces in the lecture.

Course: Composite Manufacturing – Polymers, Fibers, Semi-Finished Products, Manufacturing Technologies [2114053]

Coordinators: F. Henning
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
written
duration: 90 min
auxiliary means: none

Conditions
none

Recommendations
none

Learning Outcomes
Students know different polymer resin materials and fiber materials and can deduce their character and use.
They understand the reinforcing effect of fibers in a matrix surrounding as well as the tasks of the single components in a compound. They know about the influence of the length of fibers, their mechanical characters and performance in a polymer matrix compound.
Student know the important industrial production processes for continuous and discontinuous reinforced polymer matrix compounds.

Content
Physical connections of fiber reinforcement
Use and examples
automotive construction
transport
Energy and construction
sport and recreation
resins
thermoplastics
duromeres
mechanisms of reinforcements
glas fibers
carbon fibers
aramid fibers
natural fibers
semi-finished products - textiles
process technologies - prepregs
recycling of composites

Course: FEM Workshop – constitutive laws [2183716]

Coordinators: K. Schulz, D. Weygand
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination (ca. 30 min) in the elective module MSc, otherwise no grading
solving of a FEM problem
preparation of a report
preparation of a short presentation

Conditions
none

Recommendations
Engineering Mechanics; Advanced Mathematics; Introduction to Theory of Materials

Learning Outcomes
The student

- has the basic understanding of the materials theory and the classification of materials
- is able to independently generate numerical models using ABAQUS and can choose and apply adequate constitutive equations

Content
The course repeats the fundamentals of the theory of materials. It leads to the characterization and classification of material behavior as well as the specification by adequate material models. Here we focus on elastic, viscoelastic, plastic, and viscoplastic deformation behavior. Introducing the finite element program ABAQUS, the students learn how to analyze the material models numerically. Therefore ABAQUS-own and continuative constitutive equations are chosen.

Literature
Peter Haupt: Continuum Mechanics and Theory of Materials, Springer; ABAQUS Manual; Lecture notes

Course: Fabrication Processes in Microsystem Technology [2143882]

Coordinators: K. Bade
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination, 20 minutes

Conditions
none

Recommendations
Lectures
Mikrosystemtechnik I [2141861] and/or II [2142874]

Learning Outcomes
The student

- collects advanced knowledge
- understands process conditions and process layout
- gains interdisciplinary knowledge (chemistry, manufacturing, physics)

Content
The lecture offers an advanced understanding of manufacturing processes in microsystem technology. Basic aspects of microtechnological processing will be introduced. With examples from semiconductor microfabrication and microsystem technology the base processing steps for conditioning and finishing, patterning, removal are imparted. Nano-patterning is covered is also included and the micro-nano interface is discussed. By the help of typical processing steps elementary mechanisms, process execution, and equipment are explained. Additionally quality control, process control and environmental topics are included

Media
pdf files of presentation sheets

Literature
M. Madou
Fundamentals of Microfabrication
CRC Press, Boca Raton, 1997
W. Menz, J. Mohr, O. Paul
Mikrosystemtechnik für Ingenieure
Dritte Auflage, Wiley-VCH, Weinheim 2005
L.F. Thompson, C.G. Willson, A.J. Bowden
Introduction to Microlithography
2nd Edition, ACS, Washington DC, 1994

Course: Solid State Reactions and Kinetics of Phase Transformations (with exercises) [2193003]

Coordinators: P. Franke
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination (30 min)

Conditions

- Bacic course in materials science and engineering
- Basic course mathematics
- physical chemistry

Recommendations
knowledge of the course "Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria" (Seifert)

Learning Outcomes
The students acquire knowledge about:

- diffusion mechanisms
- Fick's laws
- basic solutions of the diffusion equation
- evaluation of diffusion experiments
- interdiffusion processes
- the thermodynamic factor
- parabolic growth of layers
- formation of pearlite
- microstructural transformations according to the models of Avrami and Johnson-Mehl
- TTT diagrams

Content
1. Crystal Defects and Mechanisms of Diffusion
2. Microscopic Description of Diffusion
3. Phenomenological Treatment
4. Diffusion Coefficients
5. Diffusion Problems; Analytical Solutions
6. Diffusion with Phase Transformation
7. Kinetics of Microstructural Transformations
8. Diffusion at Surfaces, Grain Boundaries and Dislocations
9. Numerical treatment of diffusion controlled phase transformations

Literature
1. J. Crank, „The Mathematics of Diffusion", 2nd Ed., Clarendon Press, Oxford, 1975.
2. J. Philibert, „Atom Movements", Les Éditions de Physique, Les Ulis, 1991.
3. D.A. Porter, K.E. Easterling, M.Y. Sherif, „Phase Transformations in Metals and Alloys", 3rd edition, CRS Press, 2009.
4. H. Mehrer, „Diffusion in Solids", Springer, Berlin, 2007.

Course: Finite Volume Methods for Fluid Flow [2154431]

Coordinators: C. Günther
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
None.

Recommendations
Fundamental Knowledge about Fluid Mechanics

Learning Outcomes
Students can describe all fundamental aspcets of the finite volume methods, which form the basis for a number of different commerical CFD codes. Students become familiar with the basics of the generation of unstructured meshes.

Content
The Finite Volume Method (=FVM) is nowadays of great interest, as it guarantees conservation of all relevant variables and as it can be used on nearly arbitrary meshes. By this it is a fundamental tool for numerical simulation of flows, which plays an ever growing role for construction and engineering and is the basis of several commercial or research codes as CFX, STAR-CCM+, FLUENT or OpenFOAM. The lecture is concerned with all aspects of FVM, mesh generation is also included. Newer developments as CVFEM (control volume based FEM) are described.

- Introduction
- Conservative schemes
- Finite volume method
- Analysis of FVM
- CVFEM as conservative FEM
- FVM for Navier-Stokes Equations
- Basics of mesh generation

Remarks
The lecture is recommended for students of mechanical, chemical or electrical engineering and is also of interest for people which are interested in FVM in a context other than fluid flow problems.

Course: Fluid-Structure-Interaction [2154401]

Coordinators: M. Mühlhausen, B. Frohnapfel
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam
Duration: 30 min
no auxiliary means

Conditions
none

Recommendations
Basic Knowledge about Fluid Mechanics

Learning Outcomes
The students are familiar with the numerical treatment of coupled problems and can explain this coupling with examples. After completing this course students are able to describe a fluid-structure coupled problem and to derive its numerical formulation. They are familiar with the different coupling possibilities between the two regions and can contrast the respective advantages and disadvantages. The students can describe specific problems as occur due to the coupling; furthermore, they are capable to outline strategies to overcome such issues. Finally, the students are aware of the fact that not every result of a numerical simulation necessarily reflects reality and can thus critically judge the numerically obtained results.

Content
The lecture first introduces/recalls the fundamental governing equations that describe fluids and structures. After the characterization of the problem, the relevant equations are discussed and geometry and grid generation are treated. The resulting partial differential equations are transformed into an algebraic set of equations using different DFG and CSD methods and discretization schemes. Different methods for fluid structure coupling are introduced, where the resulting stability problem is treated in detail. Finally, the obtained result is critically examined in terms of errors and inaccuracy and verification and validation procedures are introduced.
The lecture includes an introduction to function of CFG-Programs and Matlab routines that are related to the theoretically discussed approaches.

Literature
will be introduced during the lecture

Remarks
Block course with limited number of participants, registration in the secretary's office required.
See details at www.istm.kit.edu

Course: Fluid Technology [2114093]

Coordinators: M. Geimer, M. Scherer, L. Brinkschulte

Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
The assessment consists of a writen exam (90 minutes) taking place in the recess period.

Conditions
None.

Learning Outcomes
The students will be able to

- know and understand physical principles of fluid power systems
- know the current components and their operating mode
- know the advantages and disadvantages of different components
- dimension the components for a given purpose
- calculate simple systems

Content
In the range of hydrostatics the following topics will be introduced:

- Hydraulic fluids
- Pumps and motors
- Valves
- Accessories
- Hydraulic circuits.

In the range of pneumatics the following topics will be introduced:

- Compressors
- Motors
- Valves
- Pneumatic circuits.

Literature
download of lecture Fluidtechnik slides via ILIAS

Course: Fusion Technology A [2169483]

Coordinators: R. Stieglitz, Fietz, Day, Boccaccini
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral: Acceptance for the oral test only by certification of attendance of excercises
(can be given in english)
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
appreciated is knowldege in heat ans mass transfer as well as in electrical engineering
Basic knowledge in fluid mechanics, material sciences and physics

Learning Outcomes
The lecture describes the functional principle of a fusion reactor, starting from the plasma and its confinement options, the magnets, the tritium and fuel cycle, the vacuum technology and the associated material sciences. The physical principles are discussed and scaling laws are formulated. One major emphasis is directed towards the interface between the individual fields of disciplines which to a large extend determines the technological scaling of a fusion facility.Here methods are communicated, which allow for an identification of central parameters and a corresponding technical analysis. Based on the elaborated acquisition skills appoaches to design solution strategies are transmitted. Also technical solutions are shown and the weaknesses are discussed and evaluated.

Content
Actual energy situation and perspectives. Elementary particle physics, principles of nuclear fusion and nuclear fission. What is a plasma and how it can be confined? How stable is a plasma and condtions for an ignition , control of a plasma and transport in plasmas. Plasmas are confined contactless by means of magnetic fields. Hence fundamentals of the magnet technology, super-conductivity, materials in super-conductivity, fabrication and design of magnets are elaborated.A fusion reactor breeds is own fuel Tritium, which is radioactive. Tritium poses specific requirements regarding separation, conditioning and the fuel cycle, for which the physical and technological basis are outlined. Fusion plasmas are characterized by a small particle density and hence a vacuum is required. Simultaneously plasmas generate high temperatures and heat loads necessitating dedicated designs of plasma facing components at a considerable neutron irradiation. in both technology fields the tasks, requirements and challenges are formulated and how they translate to the current "state of the art" are illustrated. Moreover, an introduction into design criteria and calculation methods to select adequate vacuum pumps and to design plasma facing components is provided.

Media
Päsentation (transparencies nearly exclusivley in english) complemented by print-outs

Literature
Within each subblock an adequate selection of literature is given. Additionally the students get the lecuture materials in printed and electronic version.

Course: Fusion Technology B [2190492]

Coordinators: R. Stieglitz, Fischer, Möslang, Gantenbein
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Completed set of practical courses within lecture

Duration: approximately 25 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
attendance of fusion technology A lecture
reliable capability to use fundamental knowledge communicated in the bachelor study in physics, material sciences , electrical engineering and engineering design

Learning Outcomes
Goal of the lecture is the transfer of fundamental knowledge in material science under irradiation, nuclear physics, plasma heating technologies and the specific environment of nuclear installations (nulcear safety and scaling). In this context the focus is directed towards the elaboration of the physics fundamentals and the corresponding computational methods. Another focus is to enable the identifaction of interfaces between different technical systems and the education to assess their functionality. At the end of each block the knowledge is applied to current state of the art systems developed.
The lecutre is accompanied by excercises at the campus north (2-3 noons per topic)

Content
Fusiontechnology B comprises the following content:Fusion neutronics, material sciences under irradiation, plasma heating-and current drive methods as well as reactor safty and scaling.
The section fusion neutronics scopes the fundamentals and calculation methods, which allows for a physical design of a nuclear fusion reactor and the corresponding components (such as blankets, divertors, shielding, activation and shut down dose rate).
Within the material sciences the fundamentals of material sciences are refreshed in order to discuss subsequently material defects originating mainly from neutron irradiation. Based on this critiera to modify material properties are elaborated and options/methods to optimize materials as well as to select them adequately are deduced.
The arrangement of the plasma facing components in a fusion power plant translated into challenging demands for the system integration and energy conversion. To ignite the plasma extreme temperatures of several million degrees are required. For this purpose, special plasma heating techniques are used such as electron cyclotron resonance heating (ECRH), ion-cyclotron resonance heating (ICRH), the current drive at the lower hybrid frequency, and the neutral particle injection. Their basic mode of action, the design criteria, the transmission options and performance are presented and discussed. Additionally the heating method used also for plasma stabilization. Here are some considerations and limitations are presented.
A fusion power plant is a nuclear facility and hence it is subject of a nuclear safety evaluation and demonstration. In this context the fundamentals of the analysis and assessment of nuclear plants are described starting from the safety concept to its demonstration with the corresponding computational methods.

Media
presentation and complementing printouts, material is regularly provided via ILAS (password protected)

Literature
Lecture notes

McCracken, Peter Scott, Fusion, The Energy of Universe, Elsevier Academic Press, ISBN: 0-12-481851-X
additional literature sources for the individual topics is provided.

Course: Combined Cycle Power Plants [2170490]

Coordinators: T. Schulenberg
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral Examination ca. 30 min

Conditions
None.

Recommendations
Knowlegde in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.
We recommend to combine the lecture with the Simulator Exercises for Combined Cycle Power Plants (2170491)

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in power plant engineering. The participants can name the most important components of the combined cycle power plant and describe their function. They can design or modify combined cycle power plants independently and creatively. They have acquired a broad knowledge of this power plant technology, including specific knowledge of gas turbine design, steam turbine design and boiler design. On this basis, they can describe and analyze the specific behavior of the power plant components as well as the entire power plant in the grid. Participants in the lecture have a trained analytical thinking and judgment in power plant design.

Content
Layout of a combined cycle power plant, design and operation of gas turbines, of the heat recovery steam generator, of the feedwater system and cooling systems. Design and operation of steam turbines, of the generator and its electrical systems. System response to challinging grids, protection systems, water make-up and water chemistry. Design concepts of different power plant manufacturers, innovative power plant concepts.

Media
Lecture with English Power Point Presentation

Literature
Power point slides, lecture notes and other lecture material will be provided.
Recommended additional literature:
C. Lechner, J. Seume, Stationäre Gasturbinen, Springer Verlag, 2. Auflage 2010

Course: Gasdynamics [2154200]

Coordinators: F. Magagnato
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Duration: 30 min
no auxiliary means

Conditions
none

Recommendations
basic skills in mathematics, physics and fluid dynamics

Learning Outcomes
The students can describe the governing equations of Gas Dynamics in integral form und the associated basics in Thermodynamics. They can calculate compressible flows analytically. The students know how to derive the Rankine-Hugoniot curve and the Rayleigh line and can name those. They can derive the continuity-, the momentum- and the energy equations in differential form. With the help of the stationary flow filament theory they can calculate the normal shock wave and the associated increase of entropy.
They are able to determine the stagnation values of the gas dynamic variables and to determine their critical values. The students can apply the flow filament theory for variable cross-sectional areas and can distinguish the related different flow states inside the Laval nozzle.

Content
This lecture covers the following topics:

- Introduction, basics of Thermodynamics
- Governing equations of gas dynamics
- Application of the conservation equations
- The transport equations in differential form
- Stationary flow filament theory with and without shock waves
- Discussion of the energy equation: Stagnation and critical values
- Flow filament theory for variable cross-sectional areas. Flow inside a Laval nozzle

Literature
John, J., and Keith T. Gas Dynamics. 3rd ed.
Harlow: Prentice Hall, 2006
Rathakrishnan, E. *Gas Dynamics*. Prentice Hall of India Pvt. Ltd, 2006

Course: Gas Engines [2134141]

Coordinators: R. Golloch
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination, duration 25 min., no auxillary means

Conditions
none

Recommendations
Knowledge about „Verbrennungsmotoren A und B“ or “Fundamentals of Combustion Engines I and II”

Learning Outcomes
The student can name and explain the function, characteristics and application areas of gas and dual fuel engines. He is able to distinguish from engines using liquid fuels. The student describe and explain gaseous fuels, engine subsystems, combustion processes and exhaust gas aftertreatment technologies. He is capable to analyse and evaluate current development areas and technical challenges.

Content
Based on the basics of internal combustion engines the students learn about functions of modern gas and dual fuel engines. Core learning areas are gaseous fuels, combustion processes including abnormal combustion characteristics, subsystems like gas admission, ignition, safety and control systems. Further knowledge will be teached on emissions, exhaust gas aftertreatment, applications and operation characteristics.

Media
Lecture with PowerPoint slides

Literature
Lecture Script, prepared by the lecturer. Obtainable at the Institut für Kolbenmaschinen
Recommended:
- Merker, Schwarz, Teichmann: Grundlagen Verbrennungsmotoren, Vieweg + Teubner Verlag 2011;
- Zacharias: Gasmotoren, Vogel Fachbuch 2001

Course: Microstructure Characteristics Relationships [2178124]

Coordinators: P. Gruber
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	de

Learning Control / Examinations
oral exam

Conditions
None.

Learning Outcomes
Materials are loaded by different mechanical stresses, that can lead to differnt reasons and forms of damage and failure. The lecture treats in detail different mechanical properties and rge underlying physical mechanisms, which depend strongly on the used material (metals, ceramics, polymers,composites). A understanding of the relations between microsteructure and defects and the mechanical properties shall be reached.

Content
The following subjects are treated for the different material classes:
- plasticity
- fracture mechanics: experimental methods and analytical description of crack propagation and material behaviour at cracks
- fatigue: cyclic plasticity, riss initiation and propagation, damage analysis
- creep:time dependent plastic deformation and creep fracture

Besides the description of the material behaviour an overview of the corresponding experimental methods for mechanical characterisation will be given.

Course: Foundry Technology [2174575]

Coordinators: C. Wilhelm
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam; about 25 minutes

Conditions
Materials Science I & II must be passed.

Learning Outcomes
The students know the specific moulding and casting techniques and are able to describe them in detail. The students know the application of moulding and casting techniques concerning castings and metals, their advantages and disadvantages in comparison, their application limits and are able to describe these in detail.
The students know the applied metals and are able to describe advantages and disadvantages as well as the specific range of use.
The students are able, to describe detailed mould and core materials, technologies, their application focus and mould-affected casting defects.
The students know the basics of casting process of any casting parts concerning the above mentioned criteria and are able to describe detailed.

Content
Moulding and casting processes
Solidifying of melts
Castability
Fe-Alloys
Non-Fe-Alloys
Moulding and additive materials
Core production
Sand reclamation
Design in casting technology
Casting simulation
Foundry Processes

Literature
Reference to literature, documentation and partial lecture notes given in lecture

Course: Global Production and Logistics - Part 1: Global Production [2149610]

Coordinators: G. Lanza
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Performance is assessed in the form of one oral examination in the case of "Kernfach". Therefore, the examination date can be defined individually.
Performance is assessed in the form of one written examination during the lecture-free period.
The examination will take place once every semester and can be retaken at every official examination date.

Conditions
None

Recommendations
Combination with Global Production and Logistics – Part 2

Learning Outcomes
The students . . .

- can explain the general conditions and influencing factors of global production.
- are capable to apply defined procedures for site selection and to evaluate site decisions with the help of different methods.
- are able to select the adequate scope of design for site-appropriate production and product construction case-specifically.
- can state the central elements in the planning process of establishing a new production site.
- are capable to make use of the methods to design and scale global production networks for company-individual problems.
- are able to show up the challenges and potentials of the departments sales, procurement as well as research and development on global basis.

Content
Target of the lecture is to depict the challenges and fields of action of global operating companies and to give an overview of central aspects in global production networks as well as establishing a deepening knowledge of established methods and procedures for design and scale. Within the course methods for site selection, procedures for site specific adjustment of product construction and product technology as well as planning approaches to establish a new production site are imparted. The course is rounded off by showing the characteristics of the departments sale, procurement as well as research and development under global aspects. Moreover, the implementation of Industry 4.0 applications is discussed in the context of global production.
The topics are:

- Basic conditions and influencing factors of global production (historical development, targets, chances and threats)
- Global sales
- Site selection
- Site specific producion adjustment
- Establishing of new production sites
- Global procurement
- Design and management of global production networks

- Global research and development

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes
recommended secondary literature:
Abele, E. et al: Global Production – A Handbook for Strategy and Implementation, Springer 2008 (english)

Remarks
None

Course: Global Production and Logistics - Part 2: Global Logistics [2149600]

Coordinators: K. Furmans, O. Zimmermann
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
A performance assessment is obligatory and can be oral, a written exam, or of another kind.

Conditions
none

Recommendations
We recommend the course “Logistics - organisation, design and control of logistic systems “ (2118078) beforehand.

Learning Outcomes
Students are able to:

- assign basic problems of planning and operation of global supply chains and plan them with apropriate methods,
- describe requirements and characteristics of global trade and transport, and
- evaluate characteristics of the design from logistic chains regarding their suitability.

Content
Characteristics of global trade

- Incoterms
- Customs clearance, documents and export control

Global transport and shipping

- Maritime transport, esp. container handling
- Air transport

Modeling of supply chains

- SCOR model
- Value stream analysis

Location planning in cross-border-networks

- Application of the Warehouse Location Problem
- Transport Planning

Inventory Management in global supply chains

- Stock keeping policies

Inventory management considering lead time and shipping costs

Media
presentations, black board

Literature
Elective literature:

- Arnold/Isermann/Kuhn/Tempelmeier. HandbuchLogistik, Springer Verlag, 2002 (Neuauflage in Arbeit)

- Domschke. Logistik, Rundreisen und Touren,Oldenbourg Verlag, 1982
- Domschke/Drexl. Logistik, Standorte, OldenbourgVerlag, 1996
- Gudehus. Logistik, Springer Verlag, 2007
- Neumann-Morlock. Operations-Research,Hanser-Verlag, 1993
- Tempelmeier. Bestandsmanagement in SupplyChains, Books on Demand 2006
- Schönsleben. IntegralesLogistikmanagement, Springer, 1998

Course: Automotive Engineering I (eng.) [2113809]

Coordinators: F. Gauterin, M. Gießler
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
Written examination

Duration: 120 minutes

Auxiliary means: none

Conditions
Examination in English
Can not be combined with lecture 'Automotive Engineering I' [2113805].

Recommendations
none

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

Content
1. History and future of the automobile

2. Driving mechanics: driving resistances and driving performance, mechanics of longitudinal and lateral forces, active and passive safety

3. Drive systems: combustion engine, hybrid and electric drive systems

4. Transmissions: clutches (e.g. friction clutch, visco clutch), transmission (e.g. mechanical transmission, hydraulic fluid transmission)

5. Power transmission and distribution: drive shafts, cardon joints, differentials

Literature
1. Robert Bosch GmbH, Automotive Handbook, 9th Edition, Wiley, Chichester 2015

2. Onori S, Serrao L, Rizzoni G, Hybrid Electric Vehicles - Energy Management Strategies, Springer London, Heidelberg, New York, Dordrecht 2016
3: Reif K, Fundamentals of Automotive and Engine Technology, Springer Vieweg, Wiesbaden 2014
4: Reif K, Brakes, Brake Control and Driver Assistance Systems - Function, Regulation and Components, Springer Vieweg, Wiesbaden 2015
5: Gauterin F, Unrau H-J, Gießler M, Gnadler R, Script to the lecture 'Automotive Engineering I', KIT, Institute of Vehicle System Technology, Karlsruhe, annual update

Course: Automotive Engineering II [2114835]

Coordinators: H. Unrau
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Written Examination

Duration: 90 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture 'Automotive Engineering II' [2114855].

Recommendations
None.

Learning Outcomes
The students have an overview of the modules, which are necessary for the road holding of a motor vehicle and the power transmission between vehicle bodywork and roadway. They have knowledge of different wheel suspensions, the tyres, the steering elements and the brakes. They know different execution forms, the function and the influence on the driving or brake behavior. They are able to develop the appropriate components correctly. They are ready to analyze, to judge and to optimize the complex relationship of the different components under consideration of boundary conditions.

Content
1. Chassis: Wheel suspensions (rear axles, front axles, kinematics of axles), tyres, springs, damping devices
2. Steering elements: Manual steering, servo steering, steer by wire
3. Brakes: Disc brake, drum brake, retarder, comparison of the designs

Literature
1. Heißing, B./Ersoy, M.: Fahrwerkhandbuch: Grundlagen, Fahrdynamik, Komponenten, Systeme, Mechatronik, Perspektiven, Vieweg-Verlag, Wiesbaden, 2011

2. Breuer, B./Bill, K.-H.: Bremsenhandbuch: Grundlagen - Komponenten - Systeme - Fahrdynamik, Vieweg-Verlag, Wiesbaden, 2012

3. Gnadler, R.: Script to the lecture 'Automotive Engineering II'

Course: Basic principles of powder metallurgical and ceramic processing [2193010]

Coordinators: G. Schell, R. Oberacker
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam (20-30 min) taking place at the agreed date. The re-examination is offered upon agreement.

Conditions
None.

Recommendations
Knowledge of basic material science is assumed

Learning Outcomes
The students know the basics of characterization of powders, pastes and suspensions. They have a fundamental understanding of the process technology for shaping of particulate systems. They are able to use these fundamentals to design selected wet- and dry forming processes.

Content
The course covers fundamentals of the process technology for shaping of ceramic or metal particle systems. Important shaping methods are reviewed. The focus is on characterization and properties of particulate systems, and, in particular, on process technology for shaping of powders, pastes, and suspensions.

Media
Slides for the lecture:
available under http://ilias.studium.kit.edu

Literature

- R.J. Brook: Processing of Ceramics I+II, VCH Weinheim, 1996
- M.N. Rahaman: Cermamic Processing and Sintering, 2nd Ed., Marcel Dekker, 2003
- W. Schatt ; K.-P. Wieters ; B. Kieback. „Pulvermetallurgie: Technologien und Werkstoffe“, Springer, 2007
- R.M. German. “Powder metallurgy and particulate materials processing. Metal Powder Industries Federation, 2005
- F. Thümmler, R. Oberacker. “Introduction to Powder Metallurgy”, Institute of Materials, 1993

Course: Fundamentals of catalytic exhaust gas aftertreatment [2134138]

Coordinators: E. Lox, H. Kubach, O. Deutschmann, J. Grunwaldt
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination, Duration: 25 min., no auxiliary means

Conditions
none

Recommendations
Combustion engines I helpful

Learning Outcomes
The students can name and explain the scientific fundamentals of the catalytic exhaust gas aftertreatment, as well as the technical, political and economical parameters of its application in engines for passenger cars and HD vehicles.

The students are able to point out and explain which emissions are formed in combustion engines, why these emissions are helth-related critical and which measures the legislator has established to reduce the emissions.

Content
1. kind and source of emissions
2. emission legislation
3. principal of catalytic exhaust gas aftertreatment (EGA)
4. EGA at stoichiometric gasoline engines
5. EGA at gasoline engines with lean mixtures
6. EGA at diesel engines
7. economical basic conditions for catalytic EGA

Literature
Lecture notes available in the lectures

1. "Environmental Catalysis" Edited by G.Ertl, H. Knötzinger, J. Weitkamp Wiley-VCH Verlag GmbH, Weinheim, 1999 ISBN 3-527-29827-4
2. "Cleaner Cars- the history and technology of emission control since the 1960s" J. R. Mondt Society of Automotive Engineers, Inc., USA, 2000 Publication R-226, ISBN 0-7680-0222-2
3. "Catalytic Air Pollution Control - commercial technology" R. M. Heck, R. J. Farrauto John Wiley & Sons, Inc., USA, 1995 ISBN 0-471-28614-1
4. "Automobiles and Pollution" P. Degobert Editions Technic, Paris, 1995 ISBN 2-7108-0676-2
5. "Reduced Emissions and Fuel Consumption in Automobile Engines" F. Schaeder, R. van Basshuysen, Springer Verlag Wien New York, 1995 ISBN 3-211-82718-8
6. "Autoabgaskatalysatoren : Grudlagen - Herstellung - Entwicklung - Recycling - Ökologie" Ch. Hagelüken und 11 Mitautoren, Expert Verlag, Renningen, 2001 ISBN 3-8169-1932-4

Course: Principles of Medicine for Engineers [2105992]

Coordinators: C. Pylatiuk
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
written examination

Conditions
None.

Recommendations
Organ support systems

Learning Outcomes
Students have fundamental knowledge about functionality and anatomy of organs within different medical disciplines. The students further know about technical methods in diagnosis and therapy, common diseases, their relevance and costs. Finally the students are able to communicate with medical doctors in a way, in which they prevent misunderstandings and achieve a more realistic idea of each others expectations.

Content

- Introduction: Definitions of “health” and “disease”. History of medicine and paradigm shift towards evidence based medicine and personalized medicine.
- Special topics: nervous system, saltatory conduction, musculoskeletal system, cardio-circulatory system, narcosis, pain, respiratory system, sensory organs, gynaecology, digestive organs, surgery, nephrology, orthopaedics, immune system, genetics.

Literature

- Adolf Faller, Michael Schünke: Der Körper des Menschen. Thieme Verlag.
- Renate Huch, Klaus D. Jürgens: Mensch Körper Krankheit. Elsevier Verlag.

Course: Introduction to Microsystem Technology I [2141861]

Coordinators: J. Korvink, V. Badilita, M. Jouda

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations

The subject is concluded with a **written examination**, which can be take twice a year during the lecture breaks. For details, see the notes below.

Conditions

None.

Learning Outcomes

The lectures provide an **introduction** to the fundamentals of microsystems technology. In analogy to processes employed in the fabrication of microelectronics circuits, the **core technologies** as well as materials for producing microstructures and components are presented. Various techniques for Silicon micromachining are explained, and illustrated with **examples** for micro-components and micro-systems. Each chapter starts with its own learning goals, and ends with typical **examination questions**.

Content

The chapters are:

- **MST overview**. The broad concepts of microsystems technology are discussed.
- **Silicon wafers**. How silicon wafers are produced.
- **Technologies overview**. Which technologies typically arise in semiconductor manufacturing.
- **Solid state**. The peculiarities of the solid state, such as the arising of a band structure in semiconductors.
- **Crystal structure analysis**. How the properties of crystals are experimentally determined.
- **Materials**. Which material classes and materials are relevant in microsystems.
- **Vacuum**. The role of vacuum in semiconductor processing, and how to create vacuum.
- **Electrochemistry and electroplating**. The basics of electrochemistry, and how it can be used to form material layers.
- **Thin layers and films**. The role and properties of very thin films of materials, and how they are formed.
- **General dry etching**. How dry etching works in general.
- **Silicon dry etching**. How silicon can be anisotropically etched using gases.
- **Silicon wet etching**. How silicon can be anisotropically etched to form interesting structures.
- **Surface micromachining**. How structures are formed on the surface of a wafer.
- **Examples**. Examples of MEMS are discussed in more detail.

Literature

W. Menz, J. Mohr, O. Paul
Microsystem Technology,
Wiley-VCH, Weinheim 2005

M. Madou
Fundamentals of Microfabrication and Nanotechnology
CRC Press, 2011

Remarks
Written examinations and **practica** are offered during the lecture-free period, **twice a year**. The exact dates are communicated at the start of the semester, and follow the rule:

- The **MST practicum** takes place during the **week of Ash Wednesday** in Springtime, and in the **first full week of September** during Autumn (Fall).
- The **examination** falls on the **Thursday after the practicum** week, and is scheduled for **8:00 o'clock** in the morning.

Students may take **written examinations** in **all and any** of the following subjects on the day of the examination:

- (1 hour duration) Introduction to Microsystem Technology I
- (1 hour duration) Introduction to Microsystem Technology II
- (1 hour duration) MST practicum

The examination is given in German and English, we accept answeres in both languages. Additional resources are restricted to wordbooks of you mother tongue.

Course: Introduction to Microsystem Technology II [2142874]

Coordinators: J. Korvink, M. Jouda
Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The subject is concluded with a **written examination**, which can be take twice a year during the lecture breaks. For details, see the notes below.

Conditions
None.

Learning Outcomes
The lectures provide an **deeper insight** to the fundamentals of microsystems technology, and expand upon the topics from *Introduction to Microsystem Technology I*. More focus is placed on modern manufacturing processes which are extending the basic Silicon micromachining palette, such as nanolithography, 3D printing, and inkjet manufacturing. Each chapter starts with its own learning goals, and ends with typical **examination questions**.

Content
The chapters are:

- **Introduction**. How the market is changing, and driving MST. What the cutting edge of MST is about. How thin substrates are an enabler for future product revolutions. The modelling of microsystem effects. Definition of a system.
- **Mainstream lithography**. History of lithography. Reminder of Moore's law. Types of lithography. Resists. Masks. Mask details. Procedures. X-ray lithography in brief.
- **Lithography variants**. Responsive materials. Combining lithography with other processes. Two-photon methods. Scanning probe methods.
- **Rapid prototyping I & II**. General introduction. Fused deposition modeling. Laser sintering. Binder jetting. Laminated object manufacturing. Inkjet printing. Laser-induced forward transfer. Electrochemical. Electron beam melting. Bioprinting. Milling. Electrical discharge milling. Water jet cutting. Laser micromachining. Reasons for rapid prototyping. Advantages and disadvantages. Potential of rapid prototyping.
- **Unconventional processes I & II**. Thinking outside the box. Printed circuit board methods. Rolled up MEMS. Wirebonding. Focused ion beam. Atomic layer deposition.
- **Micro replication processes**. Introduction. Injection moulding. Reaction injection moulding. Hot embossing. Thermoforming. Blow moulding. Comparison.
- **Materials I**. Functions of a MEMS material. Feedstock types. Materials manufacturing. Spin coating. Langmuir-Blodgett films. Dip coating. Spray coating. Dispensing. Screen printing. Laser assisted processing. Inkjetting (again). Xerography. Laser assisted printing (again). Offset printing. Microcasting. MIM (again). Plasma bonding. Layering and laminating.
- **Materials II**. Material formations. Property engineering. Homogenisation. Bandgap engineering. Metamaterials. Bulk vs. film properties. Property measurements for electrical, magnetic, mechanical and other properties. In situ testing. Various measurement techniques.
- **Self assembly**. Bottom up. Types of self-assembly. Models. Forces. Enthalpy and entropy. Block copolymers. DNA origami. Directed assembly. Surface tension. Soft origami. Device assembly processes. Janus materials.

- **Exotica**. Fascinating ideas from the literature. This section is often updated and is not examined but only presented for interest.

Literature
W. Menz, J. Mohr, O. Paul
Microsystem Technology,
Wiley-VCH, Weinheim 2005
M. Madou
Fundamentals of Microfabrication and Nanotechnology
CRC Press, 2011

Remarks
Written examinations and **practica** are offered during the lecture-free period, **twice a year**. The exact dates are communicated at the start of the semester, and follow the rule:

- The **MST practicum** takes place during the **week of Ash Wednesday** in Springtime, and in the **first full week of September** during Autumn (Fall).
- The **examination** falls on the **Thursday after the practicum** week, and is scheduled for **8:00 o'clock** in the morning.

Students may take **written examinations** in **all and any** of the following subjects on the day of the examination:

- (1 hour duration) Introduction to Microsystem Technology I
- (1 hour duration) Introduction to Microsystem Technology II
- (1 hour duration) MST practicum

The examination is given in German and English, we accept answeres in both languages. Additional resources are restricted to wordbooks of you mother tongue.

Course: Foundations of nonlinear continuum mechanics [2181720]

Coordinators: M. Kamlah
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam 30 minutes

Conditions
None.

Recommendations
Engineering Mechanics - Advanced Mathematics

Learning Outcomes
The students understand the fundamental structure of a continuum theory consisting of kinematics, balance laws and constitutive model. In particular, they recognize non-linear continuum mechanics as a common structure including all continuum theories of thermomechanics, which are obtained by adding a corresponding constitutive model. The students understand in detail the kinematics of finite deformation and know the transition to the geometrically linear theory they are familiar with. The students know the spatial and material representation of the theory and the different related tensors. The students take the balance laws as physical postulates and understand their respective physical motivation.

Content
The lecture is organized in three parts. In the first part, the mathematical foundations of tensor algebra and tensor analysis are introduced, usually in cartesian representation. In the second part of the lecture, the kinematics, i.e. the geometry of deformation is presented. Besides finite deformation, geometric linearization is discussed. The thrid part of the lecture deals with the physical balance laws of thermomechanics. It is shown, how a special classical theory of continuum mechanics can be derived by adding a corresponding constitutive model. For the illustration of the theory, elementary examples are discussed repeatedly.

Literature
lecture notes

Course: Fundamentals of X-ray Optics I [2141007]

Coordinators: A. Last
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination; date request by email

Conditions
None.

Recommendations
This lecture addresses to students in mechanical engineering and physics interested in X-ray optics.
basics in optics
additional lecture: accelerator physics I/II (2208111)
http://www.imt.kit.edu/x-rayoptics.php

Learning Outcomes
The lecture will enable the students to judge capabilities of different X-ray optical imaging methods and instrumentation and to select suitable methods for a given task.

Content
The lecture covers general principles of optics as well as basics, functioning and application of reflective, refractive and diffractive X-ray optical elements and systems. Selected X-ray analytical imaging methods and the necessary optical elements are discussed including their potentials and limitations.

Literature
M. Born und E. Wolf
Principles of Optics, 7th (expanded) edition
Cambridge University Press, 2010
A. Erko, M. Idir, T. Krist und A. G. Michette
Modern Developments in X-Ray and Neutron Optics
Springer Series in Optical Sciences, Vol. 137
Springer-Verlag Berlin Heidelberg, 2008
D. Attwood
Soft X-Rays and Extreme Ultraviolet Radiation: Principles and Applications
Cambridge University Press, 1999

Remarks
Lecture dates will be fixed in agreement with the students, see institutes website.
A visit at synchrotron ANKA is possible if requested.

Course: Basics of Technical Logistics [2117095]

Coordinators: M. Mittwollen, J. Oellerich

Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

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

Learning Control / Examinations
after each lesson period; oral / written (if necessary)

Conditions
None.

Recommendations
None.

Learning Outcomes
Students are able to:

- Describe processes and machines of technical logistics,
- Model the fundamental structures and the impacts of material handling machines with mathematical models,
- Refer to industrially used machines and
- Model real machines applying knowledge from lessons and calculate their dimensions.

Content
Bases effect model of conveyor machines made for the change of position and orientation; conveyor processes; identification systems; drives; mechanical behaviour of conveyors; structure and function of conveyor machines; elements of intralogistics
sample applications and calculations in addition to the lectures inside practical lectures

Media
supplementary sheets,projector, blackboard

Literature
Recommendations during lessons

Course: Fundamentals of Combustion I [3165016]

Coordinators: U. Maas, J. Sommerer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Written exam

Conditions
Can not be combined with lecture 'Fundamentals of Combustion I' [2165515].

Recommendations
Attendance of the tutorial (3165017 - Fundamentals of Combustion I)

Learning Outcomes
After completing this course students are able to:

- explain the chemical and physical processes gorverning combustion.
- discuss diagnostic methods applied in combustion science.
- describe laminar and turbulent flames in a mathematical way.
- analyse the working principle of various technical combustion systems (e. g. piston engines, gas turbines, furnaces).
- understand the mechanisms governing pollutant formation

Content

- Ignition processes
- Fundamental concepts ans phenomena
- Experimental analysis of flames
- Conservation equations for laminar flat flames
- Chemical reactions
- Chemical kinetics mechanisms
- Laminar premixed flames
- Laminar diffusion flames
- Pollutant formation

Media
Blackboard and Powerpoint presentation

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

Remarks
Lecture number of the tutorial for this class is 3165017

Course: Fundamentals of Combustion I [2165515]

Coordinators: U. Maas

Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
Compulsory elective subject: Written exam.
In SP 45: oral exam.

Conditions
Can not be combined with lecture 'Fundamentals of Combustion I' [3165016].

Recommendations
Attendance of the tutorial (2165517 - Übungen zu Grundlagen der technischen Verbrennung I)

Learning Outcomes
After completing this course students are able to:

- explain the chemical and physical processes gorverning combustion.
- discuss diagnostic methods apllied in combustion science.
- describe laminar and turbulent flames in a mathematical way.
- analyse the working principle of various technical combustion systems (e. g. piston engines, gas turbines, furnaces).

Content

- Fundamental concepts ans phenomena
- Experimental analysis of flames
- Conservation equations for laminar flat flames
- Chemical reactions
- Chemical kinetics mechanisms
- Laminar premixed flames
- Laminar diffusion flames
- Pollutant formation

Media
Blackboard and Powerpoint presentation

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

Course: Fundamentals of Combustion II [2166538]

Coordinators: U. Maas
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
Attendance of the tutorial (2166539 - Übung zu Grundlagen der technischen Verbrennung II)

Learning Outcomes
After completing the course attendents are able to:

- explain the processes involved in ignition (auto-ignition and induced ignition).
- describe the governing mechanisms in combustion of liquid and solid fuels.
- understand the mechanisms governing pollutant formation.
- describe turbulent reacting flows by means of simple models.
- explain the occurence of engine knock.
- outline the basic numerical schemes applied in the simulation of reacting flows.

Content

- Three dimensional Navier-Stokes equations for reacting flows
- Tubulent reactive flows
- Turbulent non-premixed flames
- Turbulent premixed flames
- Combustion of liquid and solid fuels
- Engine knock
- Thermodynamics of combustion processes
- Transport phenomena

Media
Blackboard and Powerpoint presentation

Literature
Lecture notes;
Combustion - Physical and Chemical Fundamentals, Modeling and Simulation,Experiments, Pollutant Formation; Authors: U. Maas, J. Warnatz, R.W. Dibble, Springer; Heidelberg, Karlsruhe, Berkley 2006

Course: Optical Flow Measurement: Fundamentals and Applications [2153410]

Coordinators: F. Seiler, B. Frohnapfel
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
none

Learning Outcomes
The students can thoroughly describe the introduced optical measurement techniques. From recently achieve results in shock tunnels, they are able to explain the working principle(s) of the most important registration and visualization methods working with either tracer scattering or with the information obtained with light passing directly the measuring regime. Particularly, the students are qualified to comparatively discuss the measurement techniques for velocity, density and gas temperature (listed below) and can furthermore illustrate their working principles with examples:

- shadowgraph techniques
- Schlieren method
- Mach/Zehnder- and Differential interferometer
- Particle Image Velocimetry (PIV)
- Doppler Global Velocimetry (DGV)
- Doppler picture velocimetry (DPV)
- classical single-beam
- cross-beam anemometry
- interference velocimetry
- CARS-method
- laser-induced fluorescence (LIF)

Content

- Visualisations techniques
- Techniques for local point-wise measurement
- Techniques using light scattering methods
- Laser-induced fluorescence

Literature
H. Oertel sen., H. Oertel jun.: Optische Strömungsmeßtechnik, G. Braun, Karlsruhe

F. Seiler: Skript zur Vorlesung über Optische Strömungsmeßtechnik

Remarks
Block course with limited number of participants, registration in the secretary's office required.
See details at www.istm.kit.edu

Course: Hands-on BioMEMS [2143874]

Coordinators: A. Guber, T. Rajabi, R. Ahrens
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination

Conditions
none

Learning Outcomes
Together with our partners medicine and biology we would like to present the concept of organ-on-chip as part of a workshop and work together on new concepts and creative ideas. This should give an overview of the possibilities and the limits of the implementation of ideas and the development up to prototypes of such novel chip systems are to be examined. The students get a theoretical insight into the field of organ-on-chip and its application in medicine and biology. In addition the students get an insight into the world of microfluidics and microfabrication and in project generation in medical technology.

Content
Within the scope of this practical seminar, the promising field of organ-on-a-chip systems will be introduced and the relationship between theory and practice will be established. The students will learn the production techniques available at the IMT that they need for their project work in order to develop and build a functioning organ-on-chip system.

- Introduction to medical and fluidic principles, motivation and goal setting, microfabrication, material science
- Literature Research - Presentation of requirements - State of the art
- Development and evaluation of new ideas
- Conceptual design - selection of technologies
- Development
- Implementation of initial tests

Media
Lecture script

Course: Hardware/Software Codesign [23620]

Coordinators: O. Sander
Part of the modules: Compulsory Elective Module Natural Science/Computer Science/Electrical Engineering (p. 44)[MSc-Modul 11, WF NIE]

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

Learning Control / Examinations
Oral exam.

Conditions
None.

Recommendations
None.

Learning Outcomes
After completing the course, students can:

- understand the fundamentals of Hardware/Software Codedesign.
- comprehend and classify target architectures.
- apply methods for the estimation of design quality.
- describe partitioning strategies for HW/SW systems.

Content
Hardware/Software Co-design is the denomination of the concurrent and interlocked design of a system's hardware and software components. The most modern embedded systems (for example mobile phones, automotive and industrial controller devices, game consoles, home cinema systems, network routers) are composed of cooperating hardware and software components. Enabled by the rapid progress in microelectronics, embedded systems are becoming increasingly more complex with manifold application specific criteria. The deployment of computer aided design tools is not only necessary for handling the increasing complexity, but also for reducing the design costs and time-to-market. The lecture Hardware/Software Codesign discusses the needed criteria & methods and possible hardware/software target architectures on following topics:

- Target architectures of HW/SW-systems
- DSP, microcontrollers, ASIPs, FPGAs, ASIC, System-on-Chip
- Processor design: Pipelining, superscalar, cache, VLIW
- Estimation of design quality
- Hardware- and software-performance
- Methods for hardware/software partitioning
- Iterative and constructive heuristics

Interface and communications synthesis

Literature
Course material online: estudium.fsz.kit.edu
Literature: J. Teich, C. Haubelt: „Digitale Hardware/Software-Systeme-Synthese und Optimierung", Springer-Verlag, 2007 (2. Auflage)
D.D. Gajski, F. Vahid, S. Narayan, J. Gong: „Specification and Design of Embedded Systems", Prentice Hall, 1994

Course: High Performance Computing [2183721]

Coordinators: B. Nestler, M. Selzer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
5	3	Winter / Summer Term	de

Learning Control / Examinations
We regularly discuss excercises at the computer.
At the end of the semester, there will be a written exam (90 min).

Conditions
None.

Recommendations
preliminary knowlegde in mathematics, physics and materials science

Learning Outcomes
The student

- can explain the foundations and strategies of parallel programming
- can efficiently apply high performance computers for simulations by elaborating respective parallelisation techniques.
- has an overview of typical applications and the specific requirements for parallelization.
- knows the concepts of parallelisation and is capable to apply these to efficiently use high performance computing resources and the growing performance of multi core processors in science and industry.
- has experiences in programming of parallel algorithms through integrated computer exercises.

Content
Topics of the high performance computing course are:

- achitectures of parallel platforms
- parallel programming models
- key figures and performance analysis of concurrent programs
- parallelization models
- MPI and OpenMP
- parallel I/O (MPI-I/O)
- vector processing (SIMD)
- cache coherence protocols
- interconnection networks
- simple phase-field models

Media
Slides of the lecture, excercise sheets, solution files of the computer excercises.

Literature

1. Lecture Notes; Problem Sheets; Program templates
2. Foundations of Multithreaded, Parallel, and Distributed Programming, Gregory R. Andrews; Addison Wesley 2000

Course: HoC lectures [2101011]

Coordinators: M. Heilmaier
Part of the modules: Key Qualifications (p. 46)[MSc-Modul, SQL]

ECTS Credits	Hours per week	Term	Instruction language
2			

Learning Control / Examinations
s. courses

Conditions
None.

Learning Outcomes
s. courses

Content
For details of conception and contents of the courses refer to www.hoc.kit.edu/lehrangebot.

Course: High Temperature Materials [2174600]

Coordinators: M. Heilmaier
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
none

Recommendations
None

Learning Outcomes
Students are able to

- Define properly the term „high temperature“ with respect to materials
- Describe the shape of the creep curve based on underlying deformation mechanisms
- Rationalize the influence of relevant parameters such as temperature, stress, microstructure on the high temperature deformation behavior
- Develop strategies for improving creep resistance of alloys via modifying their composition
- Select properly industrially relevant high temperature structural materials for various applications

Content

- Phenomenology of High Temperature Deformation
- Deformation Mechanisms
- High Temperature Structural Materials

Literature
M.E. Kassner, Fundamentals of Creep in Metals and Alloys, Elsevier, Amsterdam, 2009

Course: Human-oriented Productivity Management: Personnel Management [2109021]

Coordinators: P. Stock
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam (ca. 20 minutes)
Compulsory attendance during the whole lecture

Conditions
None.

Recommendations

- Knowledge in Production Management/Industrial Engineering is required
- Knowledge of Work Science and Economics is helpful

Learning Outcomes
The student it capable ...

- to describe and explain the current megatrends, resulting challenges for enterprises as well as operational success factors
- to explain tasks and methods of human-oriented productivity management
- to analyse an existing working system
- to determine the available capacity and the capacity needed of a work system
- to use basic methods and tools of personnel management and to evaluate existing solutions
- to systematically design and organise the employment of staff

Content

1. Introduction: change of the working world, work organisation of successful companies, requirements for Industrial Engineering
2. Human-oriented Productivity Management
3. Organisation of enterprises:
   - Process-oriented work organisation
   - Operational and organisational structure
   - Holistic production systems
4. Basics of personnel management:
   - Identification of available capacity & capacity requirements
   - Management of working time
   - Types of mobile working
5. Systematic design of the human-resource allocation
6. Case study (group work)
7. Presentation of the solutions developed

Media

Powerpoint, exercises, case study

Literature

Handout and literature is available on ILIAS for download.

Remarks

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required

Course: Hydrodynamic Stability: From Order to Chaos [2154437]

Coordinators: A. Class
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Compulsory Elective Module Natural Science/Computer Science/Electrical Engineering (p. 44)[MSc-Modul 11, WF NIE]

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

Learning Control / Examinations
Oral
Duration: 30 minutes
Auxiliary means: none

Conditions
None.

Recommendations
Mathematics

Learning Outcomes
The studends can apply the analytic and numerical methods for an evaluation of stability properties of hydrodynamic systems. The are qualified to discuss the characteristic influence of parameter changes (e.g. Renolds number) on the calculated results with respect to the flow character and properties (e.g. transition laminar/turbulent flow).

Content
Increasing a control parameter of a thermohydraulic system, e.g. the Reynolds number, the initial flow pattern (e.g. stationary flow) can be replaced by a different pattern (e.g. turbulent flow).
Typical hydrodynamic instabilities are summarized in the lecture.
The systematic analysis of thermohydraulic stability problems is developed for the case of Rayleigh-Bernard convection (fluid layer heated from below) and selected examples from fluid dynamics.
Covered is:

- linear stability analysis: determine limiting control parameter value up to which the basic flow pattern is stable against small perturbations.
- nonlinear reduced order modeling, capable to characterize more complex flow patterns
- Lorenz system: a generic system exhibiting chaotic behavior

Media
Black board

Literature
Script

Remarks
Lecture also offered as a block-lecture within the AREVA Nuclear Professional School (www.anps.kit.edu)

Course: Industrial aerodynamics [2153425]

Coordinators: T. Breitling, B. Frohnapfel
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
None.

Learning Outcomes
Students can describe the different challenges of aerdynamical flow that occur in vehicles. They are qualified to analyze external flows around the vehicles, flows in the passenger compartments (thermal comfort), as well as cooling flows, charge motion, mixing and combustion processes in the engine.

Content
This compact lecture deals with flow, mixing and combustion phenomena with significance in vehicle development. A special focus is set on the optimization of external car and truck aerodynamics, thermal comfort in passenger compartments, analyses of cooling flows and improvement of charge motion, mixing and combustion in piston engines. These fields are explained in their phenomenology, the corresponding theories are discussed and the tools for measurement and simulation are introduced and demonstrated. The focus of this lecture is on industry relevant methods for analyses and description of forces, flow structures, turbulence, flows with heat transfer and phase transition and reactive flows. In addition an introduction to modern methods in accuracy control and efficiency improvement of numerical methods for industrial use is given. The integration and interconnection of the methods in the development processes are discussed examplary.
An excursion to the Daimler AG wind tunnel (aeroacoustic wind tunnel, climate wind tunnel, thermal measurements) and the research and development centers is offered.

- Introduction
- Industrial flow measurement techniques
- Flow simulation and control of numerical errors, turbulence modeling
- Cooling flows
- Flow mixing and combustation at direct injected Diesel engines
- Flow mixing and combustation at gasoline engine
- Vehicle aerodynamics
- HVAC-Systems and thermal comfort

Literature
Script

Remarks
Block course with limited number of participants, registration in the secretary's office required. See details at www.istm.kit.edu

Course: Introduction to Industrial Production Economics [2109042]

Coordinators: S. Dürrschnabel
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Elective Subject: oral exam (approx. 30 min)
The exam is offered in German only!

Conditions
Registration for the lecture via ILIAS is required.

Learning Outcomes

- The students know the possible organisational structures for enterprises.
- The students learn about the importance of process data as basis for efficient work structuring.
- The students are able to execute and evaluate time studies in industry (e. g. REFA).
- The students know different methods for the evaluation of workplaces.
- The students know basic techniques for the determination of wages.
- The students are able to make a cost calculation for a specific product.

Content

- Design of structural and process organisation
- Execution and evaluation of time studies
- Actual tools for time studies, e.g. Work Sampling, Methods-Time Measurement, Planned times,
- Evaluation of workplaces and determination of wages
- Cost accounting (including process costs)

Literature
Handout and literature are available on ILIAS for download.

Course: Occupational Safety and Environmental Protection (in German) [2110037]

Coordinators: R. von Kiparski
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Elective Subject: oral exam (approx. 30 min)
Optional Subject: oral exam (approx. 30 min)
The exam is offered in German only!

Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required
- Compulsory attendance during the whole lecture

Recommendations

- Knowledge of Human Factors Engineering is helpful

Learning Outcomes
The participant can

- explain the importance of occupational safety and environmental protection as well as their connection to each other.
- describe the influence of human behaviour in this context.
- explain the possibilities and limits for an engineer in this context.
- realise, wether the professional assistance of an expert of other faculties is needed.
- work through the case studies in small groups.
- evaluate and present the results of his/her work.

Content
The participants have to solve a specific case study within the field of occupational safety and environmental protection. Therefore, they work in a team. The course work covers the information research as well as the presentation of the results.

Content:

- Occupational Safety and Safety Engineering
- Environmental Protection within a Production Enterprise
- Health Management

Structure:

- Terminology
- Basics of Occupational Safety and Environmental Protection

- Case Study
- Moderated Processing of a Case Stuy within a Small Group

Literature
Handout and literature are available on ILIAS for download.

Course: Information Systems in Logistics and Supply Chain Management [2118094]

Coordinators: C. Kilger
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral / written (if necessary)

Conditions
none

Recommendations
none

Learning Outcomes
Students are able to:

- Describe requirements of logistical processes regarding IT systems,
- Choose information systems to support logistical processes and use them according to the requirements of a supply chain.

Content
1) Overview of logistics systems and processes
2) Basic concepts of information systems and information technology
3) Introduction to IS in logistics: Overview and applications
4) Detailed discussion of selected SAP modules for logistics support

Media
presentations

Literature
Stadtler, Kilger: Supply Chain Management and Advanced Planning, Springer, 4. Auflage 2008

Remarks
none

Course: Innovative Nuclear Systems [2130973]

Coordinators: X. Cheng
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations

- oral examination
- duration 20min

Conditions
None.

Learning Outcomes
This lecture is addressed to students of mechanical engineering, chemical engineering and physics. Goal of the lecture is the explanation of state-of-the-art development of nuclear systems. Nuclear systems, that are from todays point of view promising will be presented and explained. The main characteristics of such systems and the associated challenges are also part of the lecture.

Content

1. state of the art and development tendencies in nuclear systems
2. advanced concepts in light water cooled systems
3. new developments in fast reactors
4. development tendencies in gas-cooled plants
5. transmutation systems for waste management
6. fusionsystems

Course: Introduction to Neutron Cross Section Theory and Nuclear Data Generation [2190490]

Coordinators: R. Dagan
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam, 30 min.

Conditions
none

Recommendations
none

Learning Outcomes
The students:

- Understand the special importance of cross sections in various domains of natural science (Reactor physics, Material research, Solar radiation etc.)
- Are familiar with the theoretical methods and experimental effort to generate cross sections data.

Content
Cross section characterization
Summary of basic cross section theory
Resonance cross section
Doppler broadening
Scattering kernels
Basic of slowing down theory
Unit cell based XS data generation
Cross sections Data libraries
Data Measurements

Literature
Handbook of Nuclear Reactors Calculations Vol. I Y. Ronen, CRC Press 1986
D. Emendorfer. K.H. Höcker Theory of nuclear reactions, Parts I, II BI- Hochschultaschenbücher 1969 (in German)
P. Tippler, R. Llewellyn Modern Physics 2008

Course: IT-Fundamentals of Logistics [2118183]

Coordinators: F. Thomas
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral / written (if necessary)
examination aids: none

Conditions
None.

Recommendations
None.

Learning Outcomes
Students are able to:

- Describe and classify automation technology for material flow and the information technology necessary,
- identify, analyze and design the business processes in internal logistics,
- identify risks of failure and counteract and
- transfer the knowledge to practical implementations.

Content
This lecture, with exercises, treats automation technology in material flow as well as the information technology that has a direct relationship with it. In the first few chapters and exercises, an overview is given of the motors and conveying technology elements used in materials handling, and the sensors required for the purpose are explained. The target control types as well as the topic of coding techniques and RFID (GS1, barcodes, scanner, etc.) are treated in detail. Material flow controls are defined based on these chapters. Among other things, the functions of a stored-memory controller are explained in this section. Hierarchically classified control structures and
their integration in network structures are considered in detail. The principles of communications systems (bus systems etc.) are supplemented with information on the use of the Internet as well as data warehousing strategies. An overview of modern logistics systems, especially in stores administration, illustrates new problem solution strategies in the area of information technology for logistics systems. After an analysis of the causes for system failures, measures are worked
out for reducing the risks of failure. Furthermore, the objectives, task areas as well as various scheduling strategies in the area of transport management and control are presented. Worthwhile information on Europe-wide logistics concepts round off this practice-oriented lecture series. The presentation of the lectures will be multimedia-based. Exercises repeat and extend the knowledge principles imparted in the lectures and illustrate the
subject with practical examples.
Focuses:

- System architecture for logistics solutions / Modularization of conveyors
- Material Flow Control System (MFCS) / Transport Handling
- GS 1, optical reading systems, RFID
- Data communication between controllers, computers and networks
- Business processes for internal logistics – software follows function
- Adaptive IT - Future-oriented software architecture
- System stability and data backup –Software-Engineering

Literature
Detailed script can be downloaded online (www.tup.com), updated and enhanced regularly.

Course: Introduction to Ceramics [2125757]

Coordinators: M. Hoffmann
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam (30 min) taking place at a specific date.
The re-examination is offered at a specific date.

Conditions
none

Recommendations
Fundamentals in natural science are recommended for students in mechanical and industrial engineering. The lecture requires the basics of the material science courses in mechanical or industrial engineering for bachelor students.

Learning Outcomes
The students know the most relevant crystal structures and defects of non metallic inorganic materials, are able to read binary and ternary phase diagrams and are familar with powdertechnological shaping techniques, sintering and grain growth. They know the basics of the linear elastic fracture mechanics, are familar with Weibull statistics, K-concept, subcritical crack growth, creep and the opportunities for microstructural reinforcement of ceramics. The students are able to explain the correlation among chemical bonding, crystal and defect structures and the electrical properties of ceramics.

Content
After a short introduction to interatomic bonding, fundamental concepts of crystallography, the stereographic projection and the most important symmetry elements will be given. Different types of crystal structures are explained and the relevance of imperfections are analysed with respect to the mechanical and electrical properties of ceramics. Then, the impact of surfaces, interfaces and grain boundaries for the preparation, microstructural evolution and the resulting properties is discussed. Finally, an introduction is given to ternary phase diagrams.
The second part of the course covers structure, preparation and application aspects of nonmetallic inorganic glasses, followed by an introduction to the properties and processing methods of fine-grained technical powders. The most relevant shaping methods, such as pressing, slip casting, injection moulding and extrusion are introduced. Subsequently, the basics of science of sintering and the mechanisms for normal and abnormal grain growth are discussed. Mechanical properties of ceramics are analysed using basic principles of linear elastic fracture mechanics, Weibull statistics, concepts for subcritical crack growth and creep models to explain the behaviour at elevated temperatures. Furthermore it is demonstrated that mechanical properties can be siginificantly enhanced by various types of microstructural toughening mechanisms. The electronic and ionic conductivity of ceramic materials are explained based on defect-chemical considerations and band structure models. Finally, the characteristics of a dielectric, pyroelectric, and piezoelectric behaviour is discussed.

Media
Slides for the lecture:
available under http://ilias.studium.kit.edu

Literature

- H. Salmang, H. Scholze, “Keramik“, Springer
- Kingery, Bowen, Uhlmann, “Introduction To Ceramics“, Wiley
- Y.-M. Chiang, D. Birnie III and W.D. Kingery, “Physical Ceramics”, Wiley
- S.J.L. Kang, “Sintering, Densification, Grain Growth & Microstructure”, Elsevier

Course: Ceramics Processing [2126730]

Coordinators: J. Binder
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam (approx. 20 min) taking place at the agreed date.
Auxiliary means: none
The re-examination is offered upon agreement.

Conditions
none

Recommendations
Basics of the course “Introduction to Ceramics” should be known.

Learning Outcomes
The students are able to name the major ceramic process technologies and explain their specifics in detail. Additionally, they are capable of illustrating the correlations between the individual processes and their importance for the production of engineering ceramics. The students are able to relate processing effects to material properties. Furthermore the students can apply the basics to concrete tasks. They are able to comprehend and assess information in professional articles.

Content
The course imparts technological basics for processing of engineering ceramics. The course is arranged in the following units:

- Synthesis methods
- Powder conditioning and mixing methods
- Forming of ceramics
- Sintering
- Finishing processes
- Ceramic films and multi-layer systems
- Effects of processing on properties

Literature
W. Kollenberg: Technische Keramik, Vulkan Verlag 2010.
M. N. Rahaman: Ceramic Processing, CRC Taylor & Francis, 2007.
D.W. Richerson: Modern ceramic engineering, CRC Taylor & Francis, 2006.
A. G. King: Ceramic Technology and Processing, William Andrew, 2002.

Course: Nuclear Power Plant Technology [2170460]

Coordinators: T. Schulenberg, K. Litfin
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Knowledge of thermodynamics are a mandatory requirement for this course.
Basic knowledge of the physics of nuclear fission wiill be helpful.
Simulator exercises with a simplified pressurized water reactor and a simplified boiling water reactor are offered to ease understanding of thermodynamics and neutron physics.

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in nuclear power plant engineering. The participants can describe the most important components of nuclear power plants and their function. You can design or modify nuclear power plants independently and creatively. They have acquired a broad knowledge of this power plant technology, including specific knowledge of core design, design of primary and secondary systems, and of nuclear safety technologies. Based on the acquired knowledge in thermodynamics and neutron physics, they can describe and analyze the specific behavior of the nuclear power plant components and assess risks. Participants of the lecture have a trained analytical thinking and judgment in the design of nuclear power plants.

Content
Power plants with pressurized water reactors:
Design of the pressurized water reactor

- Fuel assemblies
- Control rods and drives
- Core instrumentation
- Reactor pressure vessel and its internals

Components of the primary system

- Primary coolant pumps
- Pressurizer
- Steam generator
- Water make-up system

Secondary system:

- Turbines
- Reheater
- Feedwater system

- Cooling systems

Containment

- Containment design
- Components of safety systems
- Components of residual heat removal systems

Control of a nuclear power plant with PWR
Power plants with boiling water reactors:
Design of the boiling water reactor

- Fuel assemblies
- Control elements and drives
- Reactor pressure vessel and its internals

Containment and components of safety systems
Control of a nuclear power plant with boiling water reactors

Media
Powerpoint presentations
PWR simulator
BWR simulator

Literature
lecture notes

Course: Design with Plastics [2174571]

Coordinators: M. Liedel
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam, about 20 minutes

Conditions
none

Recommendations
'Polymer Engineering I'

Learning Outcomes
Students will be able to
• distinguish polymer compounds from other construction materials regarding chemical differences, thermal behavior and solid conditions.
• discuss main plastics processes regarding advantages and disadvantages of materials selection and part geometry design and to make appropriate selections.
• analyze complex application requirements concerning material impacts on strength and to use the classic dimensioning method specific to the application to evaluate the lifetime part strength limit.
• evaluate part tolerances and geometry by appropriate methods considering molding shrinkage, production tolerances, post shrinkage, heat expansion, swelling, elastic and creep deformation.
• design plastic specific joining geometries like snap fits, screw bosses, weld seams and film hinges.
• detect classic molding failures and understand potential causes as well as to reduce the probability of molding failures by defining an optimized design.
• understand benefits and limits of selected simulation tools in the plastic technology discipline (strength, deformation, filling, warpage).
• assess polymer classes and plastic part designs with respect to suitable recycling concepts and ecological consequences.

Content
Structure and properties of plastics materials,
Processing of plastics,
Behavior of plastics under environmental impacts,
Classic strength dimensioning,
Geometric dimensioning,
Plastic appropriate design,
Failure examples,
Joining of plastic parts,
Supporting simulation tools,
Structural foams,
Plastics Technology trends.

Literature
Scriptum will be handed out during the lecture.
Recommended literature are provided in the lecture.

Course: Structural Materials [2174580]

Coordinators: K. Lang
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	de

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
None.

Learning Outcomes
The students are able to select materials for mechanical design and to dimension structural components according to the state of the art. They are familiar with the most important engineering materials. They can assess these materials on base of their characteristic properties and and they can match property profiles and requirement profiles. The dimensioning includes complex situations, such as multiaxial loading, notched components, static and dynamic loading, componetns with residual stresses and loading at high homologous temperatures.

Content
Lectures and tutorialy on the topics:
- basic loading types and superimposed loadings
- high-temperature loading
- influence of notches
- uniaxial, multiaxial and superimposed cyclic loading
- notch fatigue
- structural durability
- impact of residual stresses
- basic principles of materials selection
- dimensioning of components

Course: Lightweight Engineering Design [2146190]

Coordinators: A. Albers, N. Burkardt
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The type of examination (written or oral) will be announced at the beginning of the lecture.
written examination: 90 min duration
oral examination: 20 min duration
Auxiliary means: none.

Conditions
none

Learning Outcomes
The students are able to ...

- evaluate the potential of central lightweight strategies and their application in design processes.
- apply different stiffing methods qualitatively and to evaluate their effectiveness.
- evaluate the potential of computer-aided engineering as well as the related limits and influences on manufacturing.
- reflect the basics of lightweight construction from a system view in the context of the product engineering process.

Content
General aspects of leightweight design, lightweight strategies, construction methods, design principles, lightweight construction, stiffening techniques, lightweight materials, virtual product engineering, bionics, joining techniques, validation, recycling
Additionally, guest speakers from industry will present lightweight design from an practical point of view.

Media
Beamer

Literature
Klein, B.: Leichtbau-Konstruktion. Vieweg & Sohn Verlag, 2007
Wiedemann, J.: Leichtbau: Elemente und Konstruktion, Springer Verlag, 2006
Harzheim, L.: Strukturoptimierung. Grundlagen und Anwendungen. Verlag Harri Deutsch, 2008

Remarks
Lecture slides are available via eLearning-Platform ILIAS.

Course: Contact Mechanics [2181220]

Coordinators: C. Greiner
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam ca. 30 minutes

Conditions
none

Recommendations
preliminary knowledge in mathematics, physics and materials science

Learning Outcomes
The student

- knows models for smooth and rough surfaces under non-adhesive and adhesive conditions and understands their strengths and limits
- knows fundamental scaling relations for the functional dependency between contact area, stiffness and normal force
- can apply numerical methods to study questions from materials science

Content
The course introduces contact mechanics of smooth and rough surface for non-adhesive and adhesive interfacial conditions. There will a computer lab held in parallel to the lecture that teaches numerical approaches to contact mechanical problems.

1. Introduction: contact area and stiffness
2. Theory of the elastic half-space
3. Contact of nonadhesive spheres: Hertz theory
4. Physics and chemistry of adhesive interactions at interfaces
5. Contact of adhesive spheres: theories of Johnson-Kendall-Roberts, Derjaguin-Muller-Toporov and Maugis-Dugdale
6. Surface roughness: topography, power spectral density, structure of real surfaces, fractal surfaces as a model, metrology
7. Contact of nonadhesive rough surfaces: theories of Greenwood-Williamson, Persson, Hyun-Pei-Robbins-Molinari
8. Contact of adhesive rough surface: theories of Fuller-Tabor, Persson and recent numerical results
9. Contact of rough spheres: theory of Greenwood-Tripp and recent numerical results
10. Lateral and sliding contact: theories of Cattaneo-Mindlin, Savkoor, Persson
11. Applications of contact mechanics

Exercises are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students.

Media
lecture notes via ILIAS

Literature
K. L. Johnson, Contact Mechanics (Cambridge University Press, 1985)
D. Maugis, Contact, Adhesion and Rupture of Elastic Solids (Springer-Verlag, 2000)
J. Israelachvili, Intermolecular and Surface Forces (Academic Press, 1985)

Course: Motor Vehicle Laboratory [2115808]

Coordinators: M. Frey
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
Colloquium before each experiment
After completion of the experiments: written examination
Duration: 90 minutes
Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students have deepened their knowledge on motor vehicles acquired in lectures and can apply it practically. They have an overview of the applied measuring technique and can execute and analyse measurements for the handling of given problem definitions. They are ready to analyze and to judge measurement results.

Content
1. Determination of the driving resistances of a passenger vehicle on a roller dynamometer; measurement of the engine performance of the test vehicle

2. Investigation of a twin-tube and a single-tube shock absorber

3. Behavior of car tyres under longitudinal forces and lateral forces

4. Behavior of car tires on wet road surface

5. Rolling resistance, energy dissipation and high-speed strength of car tires

6. Investigation of the moment transient characteristic of a Visco clutch

Literature
1. Matschinsky, W: Radführungen der Straßenfahrzeuge, Verlag TÜV Rheinland, 1998

2. Reimpell, J.: Fahrwerktechnik: Fahrzeugmechanik, Vogel Verlag, 1992

3. Gnadler, R.: Documents to the Motor Vehicle Laboratory

Remarks
The admission is limited to 12 persons per group.

Course: Cooling of thermally high loaded gas turbine components [2170463]

Coordinators: H. Bauer, A. Schulz
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes
The students are able to:

- name and differentiate beween different cooling methods and analyse them
- judge on the advantages and disadvantages of cooling methods and discuss approaches for the improvement of complex cooling methods
- to outline the basics of forces convectice heat transfer and film cooling
- design colled gas turbine components in a simplified manner
- comment on the experimental and numerical methods for the characterisation of heat transfer

Content
Hot gas temperatures of modern gas turbine engines exceed the maximum tolerable material temperatures by several hundreds of K. To ensure reliability of lifetime, complex cooling technology must be applied. Various cooling methods will be introduced in this lesson. Specific pros and cons will be identified and new concepts for further improvement of cooling will be discussed. Furthermore, the fundamentals of forced convection heat transfer and film cooling wil be imparted and a simplified design process of a cooled gas turbine components will be demonstrated. Finally, experimental and numerical methods for the characterization of heat transfer will be presented.

Course: Introduction to Microsystem Technology - Practical Course [2143877]

Coordinators: A. Last
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
non-graded written examination

Conditions
none

Learning Outcomes

- Deepening of the contents of the lecture MST I and II.
- Understanding the technological processes in micro system technology.
- Experience in lab-work at real workplaces where research is normally carried out.

Content
The practical training includes eleven experiments:
1. Hot embossing of plastic micro structures
2. Micro electroforming
3. X-ray optics
4. UV-lithography
5. Optical waveguides
6. Capillary electrophoresis on a chip
7. SAW bio sensor
8. Atomic force microscopy
9. Micro mixer unit
10. Additive prototyping of micro structures
11. Combinatorial laser-induced forward transfer (cLIFT)

Each student participates in a total of five experiments which are automatically assigned.
The experiments are carried out at real workstations at the IMT and coached by IMT-staff.

Literature
W. Menz, J. Mohr, O. Paul
Microsystem Technology,
Wiley-VCH, Weinheim 2005

Course: Warehousing and distribution systems [2118097]

Coordinators: K. Furmans
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral / written (if necessary)

Conditions
none

Recommendations
logistics lecture

Learning Outcomes
Students are able to:

- Describe the areas of typical warehouse and distribution systems with the respective processes and can illustrate it with sketches,
- Use and choose strategies of warehouse and distribution systems according to requirements,
- Classify typical systsems using criteria discussed in the lecture, and
- Reson about the choice of appropriate technical solutions.

Content

- Introduction
- Yard management
- Receiving
- Storage and picking
- Workshop on cycle times
- Consoldiation and packing
- Shipping
- Added Value
- Overhead
- Case Study: DCRM
- Planning of warehouses
- Case study: Planning of warehouses
- Distribution networks
- Lean Warehousing

Media
presentations, black board

Literature
ARNOLD, Dieter, FURMANS, Kai (2005)
Materialfluss in Logistiksystemen, 5. Auflage, Berlin: Springer-Verlag

ARNOLD, Dieter (Hrsg.) et al. (2008)
Handbuch Logistik, 3. Auflage, Berlin: Springer-Verlag
BARTHOLDI III, John J., HACKMAN, Steven T. (2008)
Warehouse Science
GUDEHUS, Timm (2005)
Logistik, 3. Auflage, Berlin: Springer-Verlag
FRAZELLE, Edward (2002)
World-class warehousing and material handling, McGraw-Hill
MARTIN, Heinrich (1999)
Praxiswissen Materialflußplanung: Transport, Hanshaben, Lagern, Kommissionieren, Braunschweig, Wiesbaden: Vieweg
WISSER, Jens (2009)
Der Prozess Lagern und Kommissionieren im Rahmen des Distribution Center Reference Model (DCRM); Karlsruhe : Universitätsverlag
A comprehensive overview of scientific papers can be found at:
ROODBERGEN, Kees Jan (2007)
Warehouse Literature

Remarks
none

Course: Laser in automotive engineering [2182642]

Coordinators: J. Schneider
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination (ca. 30 min)

no tools or reference materials

Conditions
It is not possible, to combine this lecture with the lecture *Physical basics of laser technology* [2181612].

Recommendations
Basic knowledge of physics, chemistry and material science is assumed.

Learning Outcomes
The student

- can explain the principles of light generation, the conditions for light amplification as well as the basic structure and function of Nd:YAG-, CO_2- and high power diode-laser sources.
- can describe the most important methods of laser-based processing in automotive engineering and illustrate the influence of laser, material and process parameters
- can analyse manufacturing problems and is able to choose a suitable laser source and process parameters.
- can explain the requirements for safe handling of laser radiation and for the design of safe laser systems.

Content
Based on a short description of the physical basics of laser technology the lecture reviews the most important high power lasers and their various applications in automotive engineering. Furthermore the application of laser light in metrology and safety aspects will be addressed.

- physical basics of laser technology
- laser beam sources (Nd:YAG-, CO_2-, high power diode-laser)
- beam properties, guiding and shaping
- basics of materials processing with lasers
- laser applications in automotive engineering
- economical aspects
- savety aspects

Media
lecture notes via ILIAS

Literature
W. M. Steen: Laser Material Processing, 2010, Springer
W. T. Silfvast: Laser Fundamentals, 2008, Cambridge University Press

Remarks
It is allowed to select only one of the lectures “Laser in automotive engineering” (2182642) or “Physical basics of laser technology” (2181612) during the Bachelor and Master studies.

Course: Leadership and Management Development [2145184]

Coordinators: A. Ploch
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Compulsory Elective Module Economics/Law (p. 45)[MSc-Modul 12, WF WR]

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

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The students are able to name, explain und discuss the main elements of leadership theories, methods and management development basics as well as the bordering topics of change management, intercultural competences, team work and corporate governance.

Content
Leadership theories
Management tools
Communication as management tool
Change management
Management development and MD-Programs
Assessment center and management audits
Team work, team development und team roles
Intercultural competences
Leadership and ethics, Corporate Governance
Executive Coaching
Lectures of industrial experts

Course: Laboratory Exercise in Energy Technology [2171487]

Coordinators: H. Bauer, U. Maas, H. Wirbser
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
1 report, approx. 12 pages
Discussion of the documented results with the assistents

Duration: 30 minutes

no tools or reference materials may be used

Conditions
none

Recommendations
none

Learning Outcomes
Attending this course enables the students to:

- accomplish design related, experimental, numerical, analytical or theoretical tasks with a scientific background
- perform a correct evaluation of the obtained results
- adequately document and present their results in a scientific framework

Content
ITS topics
At ITS students will work on tasks, which will be defined each semester by the research asisstants, similar to topics of Bachelor- and Master-Theses. The following tasks are therefore just exemplary:

- concept for accurate repeated positioning of a camera of a robot arm
- Advanced image processing using Python
- Investigation of fuel atomization using novel mathemtical methods with MATLAB®
- Development of a post-processing routine for the determination of wetted surface area from SPH particle data
- Modelling and calculation of heat transfer and temperature profiles of test rig components applying Finite-Element-Methods
- Extension of a simulation modell to investigate spray evaporation using OpenFOAM®
- Control of the settings of an acoustic levitator using LabVIEW®

ITT topics
At the ITT students can choose between eight topics and elaborate them in groups of two.

1. Investigation of the operating behavior of a heat pump (cold steam machine) by determining the coefficient of performance (CoP) of the system as a function of the temperature level.
2. Implementing and testing of an experimental cooling tower: investigation of the mixing of cold and warm air.
3. Determination of the ignition delay of alternative fuel mixtures (bio-ethanol, methanol, diesel) with a rapid compression machine.
4. Development of alternative burner systems for cooking with alternative fuels (replacement of wood, kerosene, gases and coal).

5. Experimental investigation of burner systems to reduce pollutant emissions and increase efficiency.
6. Design of novel heat storage systems for residential heating systems / heat pumps.
7. Development of absorption refrigeration systems from the waste heat of passenger cars.
8. Influence of thermal disturbances on a laminar flow.

Remarks
The time to process the topic is 120 hours, corresponding to 4 ETCS Credits. The students have to process the topic successfully till the beginning of the following semester. Otherwise, the Laboratory Exercise is not passed and the student has to process another topic in the following semester. The processing time in the semester is flexible and shall be arranged between the supervisor and the student by mutual agreement.
The registration and the allocation of the topics takes place within the first two weeks of the lecture period on ILIAS: https://ilias.studium.kit.edu

Course: Logistics - organisation, design and control of logistic systems [2118078]

Coordinators: K. Furmans
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	de

Learning Control / Examinations
oral / written (if necessary)

examination aids: none

Conditions
None.

Recommendations
None.

Learning Outcomes
Students are able to:

- Describe logistical tasks,
- Design logistical systems suitable to the respective task,
- Dimension stocastical stock models,
- Determine essential influencing parameters on the bullwhip effect and
- Use optimizing solution methods.

Content
multistage logistic process chains
transport chain in logistic networks
distribution processes
distribution centers
logistics of production systems
dependencies between production and road traffic
information flow
cooperative strategies (like kanban, just-in-time, supply chain management)

Media
presentations, black board

Literature
None.

Remarks
none

Course: Automotive Logistics [2118085]

Coordinators: K. Furmans
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral / written (if necessary)

Conditions
None.

Recommendations
None.

Learning Outcomes
Students are able to:

- Describe essential logistic questions, in a complex production network. As an example the automobile industry is used.
- Choose and apply solution possibilities for logistic problems in this area.

Content

- Logistic questions within the automobile industry
- basic model of automobile production and distribution
- relation with the suppliers
- Disposition and physical execution
- Vehicle production in the interaction of shell, paint shop and assembly
- Sequence planning
- Assembly supply
- vehicle distribution and linkage with selling processes
- Physical execution, planning and control

Media
presentations, black board

Literature
None.

Remarks
none

Course: Airport logistics [2117056]

Coordinators: A. Richter
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral / written (if necessary)

Conditions
none

Recommendations
None.

Learning Outcomes
Students are able to:

- Describe material handling and informations technology activities on airports,
- Evaluate processes and systems on airports as the law stands, and
- Choose appropriate processes and material handling systems for airports.

Content
Introduction
airport installations
luggage transport
passenger transport
security on the airport
legal bases of the air traffic
freight on the airport

Media
presentations

Literature
„Gepäcklogistik auf Flughäfen“ àhttp://www.springer.com/de/book/9783642328527

Remarks
Limited number of participants: allocation of places in sequence of application (first come first served)
Application via “ILIAS” mandatory
personal presence during lectures mandatory

Course: Machine Vision [2137308]

Coordinators: C. Stiller, M. Lauer
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
written exam

Conditions
None.

Recommendations
Fundamental knowledge in measurement, system, and control theory is helpful, e.g. from the lecture "Measurement and Control Theory".

Learning Outcomes
Machine vision (or computer vision) describes the computer supported solution of visual tasks similar to human vision. The technical domain of machine vision includes numerical research areas like optics, digital signal processing, 3d measurement technology, and pattern recognition. Application areas for machine vision techniques can be found in automation and control, robotics, and intelligent vehicles, among others.
The lecture introduces the basic machine learning techniques and algorithms and illustrates their use. The lecture is composed out of 3 hours/week lecture and 1 hour/week computer exercises. In the computer exercises methods introduced in the lecture will be implemented in MATLAB and tested experimentally.

Content
1. Overview of machine vision
2. Image formation and image preprocessing techniques
3. Edge detection
4. Line and curve fitting
5. Color representation
6. Image segmentation
7. Camera optics and camera calibration
8. Illumination
9. 3d reconstruction
10. Pattern recognition

Literature
The slides of the lecture will be provided as pdf files. Further references will be announced in the lecture.

Course: Magnet Technology of Fusion Reactors [2190496]

Coordinators: W. Fietz, K. Weiss
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination of about 30 minutes

Conditions
None.

Recommendations
Knowledge in energy technology, power plants, material testing is welcomed

Learning Outcomes
The students know:

- Basic knowledge of superconductivity, superconducting cables and magnet construction
- Generation of low temperature, cryostat construction
- Material properties at low temperatures
- Magnet design and magnet safety
- High-temperature superconductor use in power application and magnet construction

Content
The goal of the lecture is to impart the fundamentals of construction of superconducting magnets. Magnet technology is inherently of multidisciplinary character e.g. material properties at low temperature, high voltage and high current technique. The use of superconductors is mandatory to reach highest magnetic fields with comparable small losses. Examples of magnets from power application, basic research and fusion reactor construction are discussed.
Lecture Content:

- Introduction to plasma, fusion and electromagnets
- Introduction superconductivity - basics and materials
- Creation of low temperatures, cryo-technique
- Material properties at low temperature
- Magnet design and calculation
- Magnet stability, quench safety and high voltage protection
- Magnet examples
- High-temperature superconductors (HTS)
- HTS-application (cable, motor/generator, FCL, current leads, fusion reactors)

Course: Magnetohydrodynamics [2153429]

Coordinators: L. Bühler
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Compulsory Elective Module Natural Science/Computer Science/Electrical Engineering (p. 44)[MSc-Modul 11, WF NIE]

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

Learning Control / Examinations
oral
Duration: 30 minutes
No auxiliary means

Conditions
none

Learning Outcomes
The students can describe the fundamentals of magnetohydrodynamics. They are qualified to explain the interrelations of electro and fluid dynamics so as to analyze magnetohydrodynamic flows in engineering applications or for phenomena in geo and astrophysics.

Content

- Introduction
- Basics of electro and fluid dynamics
- Exact solutions, Hartmann flow, pump, generator, channel flows
- Inductionless approximation
- Developing flows, change of cross-section, variable magnetic fields
- Alfven waves
- Stability, transition to turbulence
- Liquid dynamos

Literature
U. Müller, L. Bühler,2001,Magnetofluiddynamics in Channels and Containers, ISBN 3-540-41253-0, Springer
R. Moreau, 1990, Magnetohydrodynamics, Kluwer Academic Publisher
P. A. Davidson, 2001, An Introduction to Magnetohydrodynamics, Cambridge University Press
J. A. Shercliff, 1965, A Textbook of Magnetohydrodynamics, Pergamon Press

Course: Leadership and Conflict Management (in German) [2110017]

Coordinators: H. Hatzl
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Compulsory Elective Module Economics/Law (p. 45)[MSc-Modul 12, WF WR]

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

Learning Control / Examinations
Elective Subject: oral exam (approx. 30 min)
Optional Subject: oral exam (approx. 30 min)
Optional Subject Economics/Law: oral exam (approx. 30 min)

Conditions

- Compact course
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required
- Compulsory attendance during the whole lecture

Recommendations

- Knowledge of Work Science and Economics is helpful

Learning Outcomes

- Knowledge of techniques for management and leadership
- Preparation for management and leadership tasks in the job

Content

1. Introduction to the course
2. Goal definition and goal achievement
3. Management techniques within planning
4. Communication and information
5. Decision-making
6. Leadership and co-operation
7. Self management
8. Conflict management
9. Case studies

Literature
Handout and literature are available on ILIAS for download.

Course: Machine Dynamics [2161224]

Coordinators: C. Proppe

Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

ECTS Credits	Hours per week	Term	Instruction language
5	3	Summer term	en

Learning Control / Examinations
Written examination

Conditions
none

Recommendations
none

Learning Outcomes
Students are able to apply engineering-oriented calculation methods in order to model and to understand dynamic effects in rotating machinery. This includes the investigation of runup, stationary operation of rigid rotors including balancing, transient and stationary behavior of flexible rotors, critical speeds, dynamics of slider-crank mechanisms, torsional oscillations.

Content
1. Introduction
2. Machine as mechatronic system
3. Rigid rotors: equations of motion, transient and stationary motion, balancing
4. Flexible rotors: Laval rotor (equations of motion, transient and stationary behavior, critical speed, secondary effects), refined models)
5. Slider-crank mechanisms: kinematics, equations of motion, mass and power balancing

Literature
Biezeno, Grammel: Technische Dynamik, 2. Edition, 1953

Holzweißig, Dresig: Lehrbuch der Maschinendynamik, 1979

Dresig, Vulfson: Dynamik der Mechanismen, 1989

Course: Machine Dynamics II [2162220]

Coordinators: C. Proppe
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam, no auxiliary means allowed

Conditions
none

Recommendations
Machine Dynamics

Learning Outcomes
Students are able to develop and analyze detailed models in machine dynamics that encompass continuum models, fluid structure interaction, and stability analyses.

Content
• hydrodynamic bearings
• rotating shafts in hydrodynamic bearings
• belt drives
• virbation of turbine blades

Literature
R. Gasch, R. Nordmann, H. Pfützner: Rotordynamik, Springer, 2006

Course: Mechanical Design I [2145186]

Coordinators: A. Albers, N. Burkardt
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
Concomitant to the lecture, a workshop with 3 workshop sessions takes place over the semester. During the workshop the students are divided into groups and their mechanical design knowledge will be tested during a colloquium at the beginning of every single workshop session. The attendance is mandatory and will be controlled.
The pass of the colloquia and the process of the workshop task are required for the successful participation.
Furthermore an online test is carried out.
Further information will be announced in Ilias and at the beginning of the lecture mechanical design I.

Conditions
none

Learning Outcomes
The students are able to ...

- describe complex systems using the system technique.
- identify and formulate functional connections of a technical system.
- use the contact and channel approach (C&C^2-A).
- choose a spring and calculate it.
- identify different bearings and bearing arrangements and to select a suitable one for the particular situation.
- dimension bearing arrangements for different load cases.
- use the basic rules and principals of visualization and create a technical drawing.
- describe the functional connections of a technical system using the C&C^2-A approach and sytem theory.

Furthermore the students can describe as a team technical solutions with a gear and draw chosen components in different technical expositions.

Content
Introduction in product development
Tools for visualization (technical drawing)
Product generation as a problem solving process
Technical systems for Product generation

- systems theory
- Elementary model C&CM

Basics of selected technical components

- springs
- bearings

Concomitant to the lectures, tutorials take place with the following contents:
Gear workshop
Tutorial "tools of visualization (technical drawing)"
Tutorial "technical systems product development, sytem theory, element model C&CM"
Tutorial "springs"
Tutorial "bearing and bearing arrangements"

Media
Beamer
Visualizer
Mechanical components

Literature
Lecture note:
The lecture notes can be downloaded via the eLearning platform Ilias.
Literature:
Konstruktionselemente des Maschinenbaus - 1 und 2
Grundlagen der Berechnung und Gestaltung von
Maschinenelementen;
Steinhilper, Sauer, Springer Verlag, ISBN 3-540-22033-X
or per full text access provided by university library
Grundlagen von Maschinenelementen für Antriebsaufgaben;
Steinhilper, Sauer, Springer Verlag, ISBN 3-540-29629-8

Remarks
Lecture notes:
All lecture slides and additional information will be provided in ILIAS. All lecture notes and additional slides will be provided in Ilias.

Course: Materials and Processes for Body Lightweight Construction in the Automotive Industry [2149669]

Coordinators: D. Steegmüller, S. Kienzle
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students . . .

- are able to name the various lightweight approaches and identify possible areas of application.
- are able to identify the different production processes for manufacturing lightweight structures and explain their functions.
- are able to perform a process selection based on the methods and their characteristics.
- are able to evaluate the different methods against lightweight applications on the basis of technical and economic aspects.

Content
The objective of the lecture is to build up an overview of the relevant materials and processes for the production of a lightweight body. This includes both the actual production and the joining for the body. The lecture covers the different lightweight approaches and possible fields of application in the automotive industry. The methods are discussed with practical examples from the automotive industry.
The following topics will be covered:

- lightweight designs
- aluminum and steel for lightweight construction
- fibre-reinforced plastics by the RTM and SMC process
- joining of steel and aluminum (clinching, riveting, welding)
- bonding
- coating
- finishing
- quality assurance
- virtual factory

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Mathematical Foundation for Computational Mechanics [2162240]

Coordinators: E. Schnack
Part of the modules: Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
Oral examination. Duration: 20 minutes.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can specifically and efficiently apply the mathematical methods for modern numerics in mechanical engineering. They know and are able to describe the fundamentals of mathematical methods for elastic, dynamic, and multi-field continuum variation calculations. The students can name fundamental aspects of functional analysis and apply them to examples in order to describe and analyze error estimations in the finite element method (FEM) and the boundary element method (BEM). Based on these fundamental concepts, future challenges in mechanical engineering simulations are discussed.
The lecture notes are made available via ILIAS.

Content
Variational formulations. Functional analysis. Lagrange d process.Various function space definitions relating to the elasticity and dynamics of the mechanics. Measurements which enable the field calculation to be defined in applications.

Course: Mathematical Methods in Dynamics [2161206]

Coordinators: C. Proppe

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Mathematical Methods (p. 32)[MSc-Modul 08, MM], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

ECTS Credits	Hours per week	Term	Instruction language
5	2	Winter term	de

Learning Control / Examinations
written examination

Conditions
none

Recommendations
none

Learning Outcomes
The students know the mathematical methods of dynamics precisely. They are able to use the basic mathematical methods for modelling the dynamical behaviour of elastic and rigid bodies.
The students have a basic understanding of the description of kinematics and kinetics of bodies. They also master the alternative formulations based on weak formulations and variational methods and the approximate solution methods for numerical calculations of the moving behaviour of elastic bodies.

Content
Dynamics of continua:
Concept of continuum, geometry of continua, kinematics and kinetics of continua

Dynamics of rigid bodies:
Kinematics and kinetics of rigid bodies

Variational principles:
Priniciple of virtual work, variational calculations, Principle of Hamilto

Approximate solution methods:
Methods of weighted residuals, method of Ritz

Applications

Literature
Lecture notes (available online)

J.E. Marsden, T.J.R. Hughes: Mathematical foundations of elasticity, New York, Dover, 1994

P. Haupt: Continuum mechanics and theory of materials, Berlin, Heidelberg, 2000

M. Riemer: Technische Kontinuumsmechanik, Mannheim, 1993

K. Willner: Kontinuums- und Kontaktmechanik : synthetische und analytische Darstellung, Berlin, Heidelberg, 2003

J.N. Reddy: Energy Principles and Variational Methods in applied mechanics, New York, 2002

A. Boresi, K.P. Chong, S. Saigal: Approximate solution methods in engineering mechanics, New York, 2003

Course: Mathematical Methods in Strength of Materials [2161254]

Coordinators: T. Böhlke

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Mathematical Methods (p. 32)[MSc-Modul 08, MM], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

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

Learning Control / Examinations
depending on choice according to acutal version of study regulations
Additives as announced.

Conditions
Prerequisites are met by solution of homework problems.

Recommendations
None.

Learning Outcomes
The students can

- perform the most important tensor operatons in example problems
- classify tensors of second order according to their properties
- apply elements of tensoranalysis
- describe the kinematics of infinitesimal and finite deformations in tensorial notation
- derive balance laws of mechanics
- solve problems of elasticity and thermoelasticity using tensor notation
- apply the theoretical concepts of the lecture to special problems

Content
Tensor algebra

- vectors; basis transformation; dyadic product; tensors of 2nd order
- properties of 2nd order tensors: symmetry, anti-symmetry, orthogonality etc.
- eigenvalue problem, theorem of Cayley-Hamilton, invariants; tensors of higher order
- tensor algebra in curvilinear coordinate systems
- tensor analysis in curvilinear coordinate systems
- Differentiation of tensor functions

Application of tensor calculus in strength of materials

- kinematics of infinitesimal and finite deformations
- transport theorem, balance equations, stress tensor

- theory of elasticity
- thermo-elasticity

Literature
lecture notes
Bertram, A.: Elasticity and Plasticity of Large Deformations - an Introduction. Springer 2005.
Liu, I-S.: Continuum Mechanics. Springer, 2002.
Schade, H.: Tensoranalysis.Walter de Gruyter, New York, 1997.
Wriggers, P.: Nichtlineare Finite-Element-Methoden. Springer, 2001.

Course: Mathematical methods of vibration theory [2162241]

Coordinators: W. Seemann

Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Mathematical Methods (p. 32)[MSc-Modul 08, MM], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

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

Learning Control / Examinations
written or oral exam
Announcement 6 weeks prior to examination date.

Conditions
None.

Recommendations
Engineering Mechanics III, IV

Learning Outcomes
The students know to solve single differential equations with constant coefficients by various methods. For inhomogenious differential equations the inhomogenity may be arbitrary. They realize the relations between the different methods. For matrix-differential equations the students may derive the eigenvalue problem for free vibration and may obtain solutions for eigenvalues and eigenvectors. They know the modal transformation which is helpful to solve forced vibration. They may decide about stability of time-independent steady state solutions of nonlinear systems. They can derive boundary value problems by variational methods and know in principle how to solve them. For simple one-dimensional continua they may get analytical solutions. They can apply perturbation methods to derive analytical solutions for problems with small parameters.

Content
Linear, time-invariant, ordinary single differential equations: homogeneous solution; harmonic, periodic and nonperiodic excitations; Duhamel's integral; Fourier and Laplace transform; introduction into the theory of distributions; Systems of ordinary differential equations: matrix notation, eigenvalue theory, fundamental matrix, forced vibrations via modal expansion and transition matrix; Introduction into the dynamic stability theory; Partial differential equations: solution in product form, eigenvalue theory, modal expansion using Ritz series; Variational methods, Hamilton's principle, boundary value problems representing vibrating continua; Perturbation methods

Literature
Riemer, Wedig, Wauer: Mathematische Methoden der Technischen Mechanik

Course: Mathematical Methods in Fluid Mechanics [2154432]

Coordinators: B. Frohnapfel, D. Gatti

Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Mathematical Methods (p. 32)[MSc-Modul 08, MM], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	de

Learning Control / Examinations
written

duration: 3 hours

Aux. means: formula sheet, pocket calculator

Conditions
None.

Recommendations
Basic Knowledge about Fluid Mechanics

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

Content
The lecture will cover a selection of the following topics:

- Potential flow theory
- Creeping flows
- Lubrication theory
- Boundary-layer theory
- Laminar-turbulent transition (linear stability theory)
- Turbulent flows
- Numerical solution of the governing equation (finite difference methods)

Media
chalk board, Power Point

Literature
Kundu, P.K., Cohen, K.M.: Fluid Mechanics, Elsevier, 4th Edition, 2008
Batchelor, G.K.: An Introduction to Fluid Dynamics, Cambridge Mathematical Library, 2000
Pope, S. B.: Turbulent Flows, Cambridge University Press, 2000
Ferziger, H., Peric, M.: Computational Methods for Fluid Dynamics, Springer, 2008

Course: Mathematical Methods in Structural Mechanics [2162280]

Coordinators: T. Böhlke
Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Mathematical Methods (p. 32)[MSc-Modul 08, MM], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S]

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

Learning Control / Examinations
depending on choice according to acutal version of study regulations
Additives as announced.

Conditions
Prerequisites are met by solving exercises.

Recommendations
This course is geared to MSc students. The contents of the lecture "Mathematical methods in Strength of Materials" are a prerequisite.

Learning Outcomes
The students can

- apply methods of variational calculus for solving problems of linear elasticity
- assess mesoscopic and macroscopic können mesoskopische und makroskopische Spannungs- und Dehnungsmaße beurteilen
- apply and evaluate the methods of homogenization of elastic and thermo-elastic properties
- list methods of homogenization of elastic-plastic properties
- solve worksheet problems to topics of the lecture using technical-mathematical software

Content
Basics of variational calculus

- functionals; Frechet-differential; Gateaux-differential; maximum or minimum problems
- lemma of variational calculus and Lagrange delta-process; Euler-Lagrange-equations

Applications: Principals of continuums mechanics

- variational principals in mechanics; variational formulierung of boundary value problem of elastostatic

Applications: Homogenization methods for materials with microstructure

- mesoscopic and macroskopic stress and strain measures
- Mean values of ensembles, ergodicity
- effective elastic properties
- Homogenization of thermo-elastic properties
- Homogenization of plastic and visco-plastic properties
- Fe-based homogenization

Literature

Vorlesungsskript
Gummert, P.; Reckling, K.-A.: Mechanik. Vieweg 1994.
Gross, D., Seelig, T.: Bruchmechanik – Mit einer Einführung in die Mikromechanik. Springer 2002.
Klingbeil, E.: Variationsrechnung, BI Wissenschaftsverlag, 1977
Torquato, S.: Random Heterogeneous Materials. Springer, 2002.

Course: Mathematical models and methods in combustion theory [2165525]

Coordinators: V. Bykov, U. Maas
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
None

Learning Outcomes
The attendance of this course enables students to:

- study, understand and apply the fundamental concepts of combustion modelling,
- develop ideal models for the description of auto-ignition, explosions, flame quenching and detonations,
- understand the basic mathematical (asymptotic) methods applied in the analysis of these models,
- perform a mathematical analysis of the models,
- determine the mathematical properties of the solutions obtained from the models.

Content
The lecture shall introduce the basics of the mathematical modeling and the analysis of reacting flow systems. The fundamental models of combustion processes are outlined together with asymptotical methods, which deliver reasonable approximate solutions for numerous combustion processes. Many examples of simplified models for the description of auto-ignition, explosions, flame quenching and detonations will be presented and discussed. The main analytical methods will be illustrated using these simple examples.

Literature
Combustion Theory, F A Williams, (2nd Edition), 1985, Benjamin Cummins.
Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation, J. Warnatz, U. Mass and R. W. Dibble, (3nd Edition), Springer-Verlag, Heidelberg, 2003.
The Mathematical Theory of Combustion and Explosions, Ya.B. Zeldovich, G.I. Barenblatt, V.B. Librovich, G.M. Makhviladze, Springer, New York and London, 1985.

Course: Mathematical models and methods for Production Systems [2117059]

Coordinators: K. Furmans, M. Rimmele
Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Mathematical Methods (p. 32)[MSc-Modul 08, MM], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Winter term	en

Learning Control / Examinations
oral

examination aids: none

Conditions
none

Recommendations
Basic knowledge of statistic
recommended compusory optional subject:

- Stochastics in Mecanical Engineering

recommended lecture:

- Material flow in logistic systems (also parallel)

Learning Outcomes
Students are able to:

- Describe material flow systems with analytical solvable stochastic models,
- Derive Approches for control systems (KANBAN) based on easy models of queueing theory,
- Execute practical exercised on workstations and
- Use simulation and exakt methods.

Content

- single server systems: M/M/1, M/G/1: priority rules, model of failures
- networks: open and closed approximations, exact solutions and approximations
- application to flexible manufacturing systems, AGV (automated guided vehicles) - systems
- modeling of control approaches like constant work in process (ConWIP) or kanban
- discrete-time modeling of queuing systems

Media
black board, lecture notes, presentations

Literature
Wolff: Stochastic Modeling and the Theory of Queues, Prentice Hall, 1989

Shanthikumar, Buzacott: Stochastic Models of Manufacturing Systems

Course: Mechanics of laminated composites [2161983]

Coordinators: E. Schnack
Part of the modules: Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
Oral examination. Duration: 20 minutes.

Conditions
none

Recommendations
none

Learning Outcomes
After having attended the course, students can name the types and properties, applications as well as drawbacks and advantages of composite materials and describe them in comparison to conventional materials. Moreover, they can explain the terms “lamina,” “laminae,” and “laminate” in detail and with reference to examples. Based on this introduction, students are able to classify modern composites, particularly when they use these materials to design machine structures.
Based on the courses of technical mechanics, the students then derive the basic equations for composites. The students summarize the behavior of the components of the equations in adequate formulas and develop strategies to synthesize from individual formulas a describing formula for the formation of a material composite. Doing this, the students take into account special properties of composites (dependence on direction, temperature, air humidity) and can describe and analyze them by way of example.
Using a concrete practical example, the students independently derive adequate formulas and can describe transformation processes required for other applications. In addition, they can describe and analyze the corresponding structural behavior and, hence, develop/design materials in a goal-oriented way.
The lecture notes are made available via ILIAS.

Content
Definition of composites, definition of static and kinematic groups. Definition of material laws. Transformation of the state values of composites and transformation of the material properties for the coordinate systems in the design of machine structures.

Course: Mechanics and Strength of Polymers [2173580]

Coordinators: B. Graf von Bernstorff
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
None.

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

Learning Outcomes
The students are prepared to

- repeat the calculus on strength and design of engineering parts exposed to complex loadings,
- estimate the influence of time and temperature on the strength of polymeric materials,
- relate the strength of materials to their molecular structure, morphology and processing parameters and
- derive failure mechanisms for homogenuous polymers and composite materials therefrom.

Content
Molecular structure and morphology of polymers, temperature- and time dependency of mechanical behavior, viscoelasticity, time/temperature- superposition principle, yielding, crazing and fracture of polymers, failure criterions, impact and dynamic loading, corresponding principle, tough/brittle-transition, introduction to the principles of fiber reinforcement and multiple cracking in composites

Literature
A literature list, specific documents and partial lecture notes shall be handed out during the lecture.

Course: Mechanics in Microtechnology [2181710]

Coordinators: P. Gruber, C. Greiner
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam ca. 30 minutes

Conditions
none

Learning Outcomes
The students know and understand size and scaling effects in micro- and nanosystems. They understand the impact of mechanical phenomena in small dimensions. Based on this they can judge how they determine material processing as well as working principles and design of microsensors and microactuators.

Content
1. Introduction: Application and Processing of Microsystems
2. Scaling Effects
3. Fundamentals: Stress and Strain, (anisotropic) Hooke's Law
4. Fundamentals: Mechanics of Beams and Membranes
5. Thin Film Mechanics: Origin and Role of Mechanical Stresses
6. Characterization of Mechanical Properties of Thin Films and Small Structures: Measurement of Stresses and Mechnical Parameters such as Young'sModulus and YieldDtrength; Thin Film Adhesion and Stiction
7. Transduction: Piezo-resistivity, Piezo-electric Effect, Elektrostatics,...
8. Aktuation: Inverse Piezo-electric Effect, Shape Memory, Elektromagnetic Actuation,. . .

Literature
Folien,
1. M. Ohring: „The Materials Science of Thin Films“, Academic Press, 1992
2. L.B. Freund and S. Suresh: „Thin Film Materials“
3. M. Madou: Fundamentals of Microfabrication“, CRC Press 1997
4. M. Elwenspoek and R. Wiegerink: „Mechanical Microsensors“ Springer Verlag 2000
5. Chang Liu: Foundations of MEMS, Illinois ECE Series, 2006

Course: Laboratory mechatronics [2105014]

Coordinators: C. Stiller, M. Lorch, W. Seemann
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
certificate of successful attendance

Conditions
none

Learning Outcomes
The student is able to ...

- use his knowledge about mechatronics and microsystems technology to solve a practical problem. The laboratory course comprises simulation, bus communication, measurement instrumentation, control engineering and programming.
- integrate the different subsystems from a manipulator to a working compound system in teamwork.

Content
Part I
Control, programming and simulation of robots
CAN-Bus communication
Image processing / machine vision
Dynamic simulation of robots in ADAMS

Part II
Solution of a complex problem in team work

Literature
Manuals for the laboratory course on Mechatronics

Course: Measurement II [2138326]

Coordinators: C. Stiller
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
written examination

Conditions
None.

Recommendations
Fundamentals in measurement, system and control theory, e.g. from the lecture “Measurement and Control Systems”

Learning Outcomes
The capabilities of modern sensor technology pave the way for novel applications in engineering. Especially digital measurement techniques may be used even in very complex environments and thus have strong impact on technological progress. Stochastic models of measurement processes form the basis for meaningful information processing and provide a valuable tool for engineering. This interdisciplinary lecture addresses students in mechanical engineering and related subjects. The lecture gives an overview of digital technology and stochastics. These areas form the basics of estimation methods that can be embedded elegantly in the theory of state observers. Applications in signal processing for modern environmental perception (video, Lidar, Radar) illustrate the discussed subjects.

Content
1. Digital technology
2. Stochastic modeling for measurement applications
3. Estimation
4. Bayes & Kalman Filter
5. Environmental perception

Literature
Script in German

Course: Measurement Instrumentation Lab [2138328]

Coordinators: C. Stiller, M. Spindler
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
Colloquia

Conditions
None.

Recommendations
Basic studies and preliminary examination; basic lectures in automatic control

Learning Outcomes
The laboratory complements the course “Introduction to Measurement and Control”. While the course is organized into principles and subsystems, the laboratory presents complete measurement systems and methods for the most relevant industrial measurands.

Content
A Signal recording:
- measurement of temperature
- measurement of lengths

B Signal pre-precessing:
- bridge circuits and principles of measurement
- analog/digital transducers

C Signal processing:
- measuring stochastic signals

D Complete systems:
- system identification
- inverse pendulum
- path control of a robot

Literature
Instructions to the experiments are available on the institute’s website

Course: Metals [2174598]

Coordinators: M. Heilmaier
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	de

Learning Control / Examinations
Oral exam, about 20 minutes

Conditions
none

Learning Outcomes
The students are familiar with the thermodynamic foundations of phase transformations, the kinetics of phase transformations in the solid state, the mechanisms of microstructure formation and microstructure-property relationships and can apply them to metallic materials. They can assess the effects of heat treatments and of alloying on the microstructure and the mechanicla and physical properties of metallic materials. This competence is in particular deepened for iron- and aluminum-based alloys.

Content
Properties of pure elements; thermodynamic foundations of single-component and of binary systems, as well as multiphase systems; nucleation and growth; diffusion processes in crystalline materials; phase diagrams; effects of alloying; nonequilibrium microstructures; heat treatment technology

Literature
D.A. Porter, K. Easterling, Phase Transformation in Metals and Alloys, 2nd edition, Chapman & Hall, London 1997,
J. Freudenberger: http://www.ifw-dresden.de/institutes/imw/lectures/lectures/pwe

Course: Methods of Signal Processing [23113]

Coordinators: Puente León
Part of the modules: Compulsory Elective Module Natural Science/Computer Science/Electrical Engineering (p. 44)[MSc-Modul 11, WF NIE]

ECTS Credits	Hours per week	Term	Instruction language
6	3/1	Winter term	de

Learning Control / Examinations

Conditions
None.

Learning Outcomes
After completing the course, students are able to:

- understand the basics of signal processing theory and describe the properties and the representation of signals.
- understand the fundamentals of time frequency analysis.
- understand the theroetical background of estimation theory and apply as well as evaluate various estimation techniques.
- apply the theoretical knowledge to practical problems.

Content
This lecture is offered to master students in electrical engineering and information technology who focus deeper in the field of signal processing and estimation theory.
During the last years, time frequency analysis became an important part of signal processing theory. By means of time frequency analysis, signals with variable frequency content can be analyzed. Thus, time frequency analysis and synthesis are discussed in detail. The lecture also gives an extensive overview about parameter estimation and state estimation theory.
The lecture starts with fundamentals on signal processing. The main signal properties are discussed. Signal representation in the Hilbert space is explained and different possibilities for signal representation in basis and frame are presented.
Time frequency analysis is introduced by the short time Fourier transform (STFT). The wavelet transform, its application and realization as well as another time frequency distribution – the Wigner-Ville distribution – are discussed.
The second part of the lecture is concerned with estimation theory. After fundamental considerations on signal modeling, parameter estimation techniques are introduced. Different estimators, like least squares, Gauß-Markov and so on are derived and compared. Subsequently, model based estimation and Bayes estimation is presented. The Kalman filter is discussed for state estimation.
The lecture “Methods of Signal Processing” moderates advanced knowledge in signal processing and estimation theory. The theoretical considerations are exemplified by numerous examples of real applications.

Literature
Uwe Kiencke, Michael Schwarz, Thomas Weickert: Signalverarbeitung - Zeit-Frequenz-Analyse und Schätzverfahren, Oldenbourg, 2008.

Course: Methods and Processes of PGE – Product Generation Engineering [2146280]

Coordinators: A. Albers, N. Burkardt
Part of the modules: Product Development - Methods of Product Development (p. 29)[MSc-Modul, PE-E (2016)]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	de

Learning Control / Examinations
Written exam
Auxiliaries:

- Calculator
- German dictionary (books only)

Conditions
None

Learning Outcomes
The students are able to ...

- Classify product development in companies and differentiate between different types of product development.
- Identify the market factors relevant to product development.
- Explain the concept of innovation and the need for innovation for companies.
- Understand the description model of PGE product generation engineering and link it to relevant influences on customer satisfaction and cross-generational variations.
- Identify the strengths and weaknesses of people as problem solvers and explain how problem-solving methods support the developer.
- Identify and understand problems and use a problem-solving methodology when confronted with problems, know their process, the meaning of the individual steps and can apply them.
- Distinguish, describe and characterize different process models of product development.
- Understand the iPeM - integrated Product engineering Model, model development processes and apply the iPeM in various development situations.
- Identify and explain the central methods, assign them to the activities in the product development process and apply them in the development of mechatronic products.
- Explain the difference between verification and validation and select, describe and apply appropriate methods to perform the validation.
- Explain problem-solving systems and assign corresponding development methods.
- Explain product profiles and distinguish and select suitable creativity techniques for finding solutions / ideas.
- Understanding and applying agile processes.
- Explain the challenges of agile approaches and explain the different requirements and boundary conditions between agile software development and product generation development.
- Discuss design guidelines for the design of technical systems and apply them to the development of slightly complex technical systems.
- Name, compare and select quality assurance methods according to the specific situation and apply them to complex technical systems.

- Explain methods of statistical design of experiments.
- Explain cost generation and cost responsibility in the design process.

Content
Basic principles of product development: basic concepts, classification of product development in the market environment, overview of sales markets, role of competition and customer role, product technology and industry life cycles, market risks

- Innovation and market success: innovation process, product profiles, invention and market launch
- System and Model Theory: Error of Thought in Problem Solving, General Model Theory according to Stachowiak, System Theory of Technology according to Ropohl, Methods of Modeling, Design Structure Matrix (DSM), System Modeling Language (SysML)
- PGE - Product Generation Engineering: Explanation Model of the PGE, the Kano Model
- The concept of the problem: definition of the problem, the human being as problem solver, problem solving techniques, iterations in problem solving Problem solving technique SPALTEN: Basics of the problem solving technique SPALTEN, detailed activity sequence of SPALTEN
- Process models: Application of process models, overview of established process models
- iPeM - integrated Product engineering Model: introduction to the system Tripel, basic activities in iPeM, product development activities in iPeM
- ASD - Agile Systems Design: Challenges in the agile development of mechatronic systems, the basic principles of ASD - Agile Systems Design, application of ASD - Agile Systems Design
- Design for X: Dfx and Standardization, Design for Quality, Design for Lightweight Construction

Literature
A. Albers, N. Bursac: „PGE – Produktgenerationsentwicklung - Mit Methoden und Prozessen zur Innovation", Springer Verlag, 2019
A. Albers et al.: „PGE - Product Generation Engineering - Case Study Of The Dual Mass Flywheel", International Design Conference - DESIGN 2016, May 16 - 19, 2016, Dubrovnik - Croatia.
Albers et al.: „20 years of co-creation using case based learning – An integrated approach for teaching innovation and research in Product Generation Engineering", ICL2017, 27-29 September 2017, Budapest, Hungary
Albers et al.: „PGE – Produktgenerationsentwicklung am Beispiel des Zweimassenschwungrads", Springer-Verlag Berlin Heidelberg, 2016
Albers et al.: „Die Frühe Phase der PGE – Produktgenerationsentwicklung", Stuttgarter Symposium für Produktentwicklung, 2017
Albers et al.: „InnoFox – Situationsspezifische Methodenempfehlung im Produktentstehungsprozess", Stuttgarter Symposium für Produktentwicklung 2015
Albers et al.: „15 Years of SPALTEN Problem Solving Methodology in Product Development", NordDesign 2016, August 10 – 12, 2016, Trondheim, Norway
Albers et al.: „iPeM – integrated Product engineering Model in context of Product Generation Engineering", 26th CIRP Design Conference, Elsevier B.V., 2016
Albers et al.: "Product Profiles. Modelling customer benefits as a foundation to bring inventions to innovations", Procedia CIRP, 2018
Heimicke, Reiß et al.: „Agile Innovative Impulses In Product Generation Engineering: Creativity By Intentional Forgetting", ICDC2018, January 31st – February 2nd 2018, Bath, UK

Remarks
This lecture is the basis for the main subject Integrated Product Development, which is offered as a specialisation.

Course: Analysis tools for combustion diagnostics [2134134]

Coordinators: J. Pfeil
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination, Duration: 25 min., no auxiliary means

Conditions
none

Recommendations
Fundamentals of Combustion Engines helpful

Learning Outcomes
The students can name and explain state-of-the-art methods to analyse the process in combustion as well as special measuring techniques such as optical and laser analysis. They are able to thermodynamically model, analyse and evaluate the engine process.

Content
energy balance at the engine
energy conversion in the combustion chamber
thermodynamics of the combustion process

flow velocities

flame propagation

special measurement techniques

Literature
Lecture notes available in the lectures

Course: Microenergy Technologies [2142897]

Coordinators: M. Kohl
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
as elective subject in major field or as optional subject, oral exam, 30 minutes

Conditions
None.

Recommendations
The lecture addresses students in the fields of mechanical engineering, energy technologies, mechatronics and information technology. A comprehensive introduction is given in the basics and current developments in this new and very dynamically evolving field.
The lecture is (supplementary/compulsory) in the master course of „Micro Energy Technologies“ and supplementary in the major of „Mechatronics and Microsystems Technology“ in Mechanical Engineering.
Mechanical Engineering: Major M&M
Energy Technologies: NN
Energietechnik: NN

Learning Outcomes
- Knowledge of the principles of energy conversion
- Knowledge of the underlying concepts of thermodynamics and materials science
- Explanation of layout, fabrication and function of the treated devices
- Calculation of important properties (time constants, forces, displacements, power, degree of efficiency, etc.)
- Development of a layout based on specifications

Content
- Basic physical principles of energy conversion
- Layout and design optimization
- Technologies
- Selected devices
- Applications

The lecture includes amongst others the following topics:
Micro energy harvesting of vibrations
Thermal micro energy harvesting
Microtechnical applications of energy harvesting
Heat pumps in micro technology
Micro cooling

Literature
- Lecture notes (overhead transparencies) „Micro Energy Technologies“
- Stephen Beeby, Neil White, Energy Harvesting for Autonomous Systems, Artech House, 2010
- Shashank Priya, Daniel J. Inman, Energy Harvesting Technologies, Springer, 2009

Course: Micro Magnetic Resonannce [2141501]

Coordinators: J. Korvink, N. MacKinnon
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Own Presentation, participation at the course discussions, result is passed or failed.

Conditions
None.

Recommendations
See literature list.

Learning Outcomes
Attendees aquire fundamental insights into microsystem concepts for **nuclear magnetic resonance and imaging (NMR and MRI)**.

Content
Nuclear magnetic resonance (**NMR**), or magnetic resonance in general (**MR**) is a powerful, **non-invasive technique** useful for gaining atomic level structural details on samples ranging from soluble small molecules to large membrane bound proteins. As an imaging technology, it can provide information on morphology, composition, as well as transport phenomena. For example, it is possible to visualise fluid dynamics such as the course of blood in the body or in a microfluidic system, or the anisotropic diffusion in the brain or a porous medium. Also in the development of batteries, and in chemical engineering procedures, NMR provides quantitative and qualitative information.
Traditional NMR hardware used for exciting the sample and detecting the signal is traditionally on the macroscale in terms of physical dimensions. Recently, miniaturization of NMR systems has developed into an active research area driven primarily by the enhanced mass sensitivity and the ability for system integration with smaller NMR detectors.
In this seminar course, we will explore some of the **state-of-the-art applications** of **micro-NMR** and **nano-NMR**. A selection of representative research papers will be provided, from which each student will select one paper to learn in depth and finally present in a style as if they performed the research themselves. The course will first offer a **series of introductory lectures**, followed by a **series of tutorial sessions** in which each student may discuss with experts. Finally, individual **student presentations** with discussion will be held.
Topics to be offered:

- Novel micro-NMR detectors (solenoid, strip line, microslot, CMOS, printed, etc.)
- Novel nano-MR detectors (MRFM, NV centers, etc.)
- Computation (design optimization, MOR, MRI image processing, NMR spectral prediction, etc.)
- Signal enhancement strategies (hyperpolarization DNP, PHiP, Xe, refrigeration)
- System hyphenation (chromatography, flow cells, LoC, orthogonal analysis, etc.)
- Complex mixtures (metabolomics, in vivo applications on small organisms)
- Biomedical MR sensors (catheters, implantable, etc.)

Literature
The Links to literature journal articles will be provided to the students. Example research journal sources will include Nature, Nature Communications, Science, PNAS, JMR, etc. For general reading, some recommended sources are:

- Principles of Nuclear Magnetic Resonance Microscopy, Callaghan, P (1994), Oxford University Press.
- Spin Dynamics: Basics of Nuclear Magnetic Resonance 2nd Ed., Levitt, M (2013), John Wiley & Sons.
- NMR Probeheads for Biophysical and Biomedical Experiments – Theoretical Principles, Mispelter, J; Lupu, M; Briguet, A (2006) Imperial College Press.

Course: Microactuators [2142881]

Coordinators: M. Kohl
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
(1) as core subject in the major “Micoactuators and Microsensors” combined with the core subject “New Actuators and Sensors”, oral, 60 minutes
or
(2) as elective subject in the other major fields
or
(3) as optional subject, oral exam, 30 minutes

Conditions
None.

Recommendations
The lecture addresses students in the fields of mechanical engineering, mechatronics and information technology, materials science and engineering, electrical engineering and economic sciences. A comprehensive introduction is given in the basics and current developments on the microscopic length scale.
The lecture is core subject of the major course “Microactuators and Microsensors” of the specialization “Mechatronics and Microsystems Technology” in Mechanical Engineering.
Mechanical Engineering: Specialization M&M / Major 54

Learning Outcomes
- Knowledge of the actuation principles including pros and cons
- Knowledge of important fabrication technologies
- Explanation of layout and function of the microactuators
- Calculation of important properties (time constants, forces, displacements, etc.)
- Development of a layout based on specifications

Content
- Basic knowledge in the material science of the actuation principles
- Layout and design optimization
- Fabrication technologies
- Selected developments
- Applications

The lecture includes amongst others the following topics:

- Microelectromechnical systems: linear actuators, microrelais, micromotors
- Medical technology and life sciences: Microvalves, micropumps, microfluidic systems
- Microrobotics: Microgrippers, polymer actuators (smart muscle)
- Information technology: Optical switches, mirror systems, read/write heads

Literature
- Lecture notes
- D. Jendritza, Technischer Einsatz Neuer Aktoren: Grundlagen, Werkstoffe, Designregeln und Anwendungsbeispiele, Expert-Verlag, 3. Auflage, 2008
- M. Kohl, Shape Memory Microactuators, M. Kohl, Springer-Verlag Berlin, 2004
- N.TR. Nguyen, S.T. Wereley, Fundamentals and applications of Microfluidics, Artech House, Inc. 2002
- H. Zappe, Fundamentals of Micro-Optics, Cambride University Press 2010

Course: Microstructure characterization and modelling [2161251]

Coordinators: T. Böhlke, F. Fritzen
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
5	2	Winter term	de

Learning Control / Examinations
oral examination

Conditions
None.

Recommendations
This course is geared to MSc students.

Learning Outcomes
The students can

- list, apply and evaluate basic measures to describe the geometry of microstructured materials
- choose appropriate distribution functions for describing fibre or particle reinforced or plycrystalline materials
- list and evaluate the basic steps of algorithms for generation of synthetic structures

Content
An introduction to the statistical description of geometric properties of microstructured materials is given. Typically, particle or fibre reinforced materials and polycrystalline materials are considered. The statistical description using n-point-correlation functions is described as well as characteristic measures and distribution functions (fibre or crystal orientation distribution functions) are discussed. Additionally, methods for generation of synthetic structures are considered which are typical input data for numerical multiscale simulations.

Literature
Torquato, S.: Random heterogeneous materials: microstructure and macroscopic properties, Springer, New York, 2002.
Ohser, J., Mücklich, F.: Statistical Analysis of Microstructures in Materials Science, Statistics in Practice, John Wiley & Sons, 2000.

Course: Modelling of Microstructures [2183702]

Coordinators: A. August, B. Nestler, D. Weygand

Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
We regularly hand out exercise sheets. The individual solutions will be corrected.
oral exam ca. 30 min

Conditions
none

Recommendations
materials science
fundamental mathematics

Learning Outcomes
The student can

- explain the thermodynamic and statistical foundations for liquid-solid and solid-solid phase transition processes and apply them to construct phase diagrams.
- explain the mechanisms of grain and phase boundary motion induced by external fields
- use the phase-field method for simulation of microstructure formation processes using modeling approaches and challenges of current research
- has experiences in computing and conduction simulations of microstructure formation from an integrated computer lab.

Content
- Brief Introduction in thermodynamics
- Statistical interpretation of entropy
- Gibbs free energy and phase diagrams
- Auxiliarythermodynamic functions
- Phase diagrams
- Phase transformations and driving forces
- The Energy functional and the surface tension
- The phase field equation
- Conservation equations
- A multicomponent multiphase field model
- Onsager reciprocal relations

Media
Black board and slides, laptops for computer lab, exercise sheets

Literature

1. Gottstein, G. (2007) Physikalische Grundlagen der Materialkunde. Springer Verlag Berlin Heidelberg
2. Kurz, W. and Fischer, D. (1998) Fundamentals of Solidification. Trans Tech Publications ltd, Switzerland Germany UK USA
3. Porter, D.A. Eastering, K.E. and Sherif, M.Y. (2009) Phase transformation in metals and alloys (third edition). CRC Press, Taylor & Francis Group, Boca Raton, London, New York
4. Gaskell, D.R., Introduction to the thermodynamics of materials

Course: Model based Application Methods [2134139]

Coordinators: F. Kirschbaum
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
take-home exam, short presentation with oral examination

Conditions
none

Recommendations
knowledge in Basics of combustion engines, vehicular systems, control theorie and statistics.

Learning Outcomes
The student can name the most important methods for model-based calibration of powertrain ECUs. Particulary he can choose and apply the correct approach for empirical modeling for a given powertrain calibration task (fuel consumption, emissions, air path, driveability, etc.) and type of plant (linear-nonlinear, static-dynamic, etc.). He is capable to solve typical Problems of a calibration engineer of automotive OEMs or suppliers.

Content
The efforts for the calibration of automotive powertrain ECUs are increasing due to new engine or powertrain technologies and tightening emission laws. From a present view only model based calibration methods are capable to handle this situation. The lecture presents a selection of practice-proofed model-based calibration methods.

Media
Lecture notes, blackboard, presentations and life demonstrations via projector

Course: Modeling and Simulation [2185227]

Coordinators: C. Proppe, K. Furmans, B. Pritz, M. Geimer
Part of the modules: Modeling and Simulation (p. 31)[MSc-Modul 05, MS]

ECTS Credits	Hours per week	Term	Instruction language
7	4	Winter term	de

Learning Control / Examinations
written exam, 3 hours

Conditions
none

Recommendations
none

Learning Outcomes
The student:

- has an overview of modelling and simulation techniques typical in mechanical engineering ,
- obtains the ability to carry out simulation studies starting from the formulation of problems by concepts, implementation, verification and validation,
- exercises complex simulation studies.

Content
Introduction: Overview, concept formation, simulation studies, time/event-discrete models, event-oriented/process orientated/transaction-oriented view, typical model classes (operation/maintenance, storekeeping, loss-susceptible systems)
Time-continuous models with concentrated parameters, model characteristics and model analysis Numerical treatment of ordinary differential equations and differential-algebraic sets of equations coupled simulations with concentrated parameters
Time-continuous models with distributed parameters, description of systems by means of partial differential equations, model reduction, numerical solution procedures for partial differential equations

Media
presentations

Literature
None.

Remarks
none

Course: Modeling of Thermodynamical Processes [2167523]

Coordinators: R. Schießl, U. Maas
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Winter / Summer Term	de

Learning Control / Examinations
Oral exam
Duration: 30 min.
With attendance on exam prerequisite: 6 Credits
Without attendance on exam prerequisite: 4 Credits

Conditions
None

Recommendations
None

Learning Outcomes
After completing the course the students are able to:

- formulate thermodynamical basics in a mathematical scheme
- abstract and model complex thermodynamic processes.
- determine and implement adequate numerical schemes for the solution of the resulting systems of equations.

Content
Basics of Thermodynamics
Numerical solver strategies for algebraic equations
Optimization issues
Ordinary and partial differential equations
Application to various problems in thermodynamics (engine processes, determination of equilibrium states, unsteady processes in inhomogeneous systems)

Literature
Lecture notes
Numerical Recipes; Cambridge University Press
R.W. Hamming; Numerical Methods for scientists and engineers; Dover Books On Engineering; 2nd edition; 1973
J. Kopitz, W. Polifke; Wärmeübertragung; Pearson Studium; 1. Auflage

Course: Numerical methods and simulation techniques [2183703]

Coordinators: B. Nestler
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT]

ECTS Credits	Hours per week	Term	Instruction language
5	3	Winter / Summer Term	de

Learning Control / Examinations
We regularly hand out exercise sheets. In addition, the course will be accompanied by practical exercises at the computer.
Precondition to register for the written exam is the successful participation in the accompanying computer lab by presenting the solved excercise sheets at the PC.
written examination: 90 minutes

Conditions
None.

Recommendations
preliminary knowlegde in mathematics, physics and materials science

Learning Outcomes
The student can

- explain the basic algorithms and numerical methods which are beside other applications relevant for materials simulations.
- describe and apply numerical solution methods for partial differential equations and dynamical systems
- apply numerical methods to solve heat and mass diffusion problems which can also be used to model microstructure formation processes
- has experiences in how to implement and program the introduced numerical methods from an integrated computer lab.

Content
The course gives an introduction to modelling and simulation techniques.
The following topics are included:

- polynom interpolation methods, splines, Taylor series
- zero point algorithms
- regression methods
- numerical differentiation and integration
- finite difference method
- dynamical systems, ordinary partial differential equations
- numerics of partial differential equations
- mass and heat diffusion equation
- computer lab in the programming language C, practical exercises

In parallel to the lecture, regular exercise sheets are provided and discussed. In addition, the course will be accompanied by practical exercises at the computer. Precondition to register for the written exam is the successful participation in the accompanying computer lab by presenting the solved excercise sheets at the PC.

Media
Slides and black board. The slides will be provided as a manuscript for the course.

Literature

1. Scientific Computing, G. Golub and J.M. Ortega (B.G.Teubner Stuttgart 1996)

Course: Modern Software Tools in Power Engineering [23388]

Coordinators: T. Leibfried
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Oral test at the beginning of the internship
Duration: 15-20 minutes plus discussion
Written report about the results of the experiments performed during the internship

Conditions
none

Recommendations
none

Learning Outcomes
After completing the course students can:

- apply commercial software for calculating magnetic and electric field.
- apply commercial software for power grid calculations.

Content
During this practical course students will be able to work with three power engineering software tools. Participants should individually solve three typical engineering tasks:

- · **Modelling a high voltage bushing using finite element software "Maxwell".**
  In this module students will design a high voltage transformer bushing which resists high electric field stress. Using a finite element software it is possible to determine critical values already during the design phase, before producing costly models or prototypes.
- · **Development and Validation of an elevator control system based on a Siemens Simatic S7 PLC**

The PLC software Simatic S7 is a standard system for all kinds of industrial automation and control tasks. It consists of several programs which can be individually configured. During this course module students will be able to develop a control system which can be tested on a physical elevator model.
· **Load Flow Calculation of an industrial distribution grid using grid simulation software „DIgSILENT Powerfactory"**
The intention of this network analysis module is to understand the theory of load flow and short circuit calculation and to get familiar with its usage in practice. Further, an insight in real network calculation software shall be imparted.

Media
Blackboard and Powerpoint presentation

Literature
Course note packet
P. Kundur
"Power System Stability and Control"
McGraw-Hill Inc., 1994, ISBN 0-07-035958-X
N. G. Hingorani, L. I. Gyugyi
"Understanding FACTS"
Institute of Electrical and Electronics Engineers Inc., 2000, ISBN 0-7803-3455-8

Course: Modern Physics for Engineers [4040311]

Coordinators: B. Pilawa

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

ECTS Credits	Hours per week	Term	Instruction language
5	2	Summer term	de

Learning Control / Examinations
Written exam. The written exam is scheduled in the beginning of each semester.
Duration of Examination: 180 min.

Conditions
Solid mathematical background, basic knowledge in physics.

Learning Outcomes
The students

- are familiar with the basic experimental results leading to relativistic physics
- understand the principles of relativity
- comprehend the coherence of the particle and wave description of light and matter
- understand the basic principles leading to the Dirac- and Schrödinger-equation
- are able the apply the Schrödinger-equation to basic problems in quantum mechanics
- comprehend the limits of wave mechanics
- have a good understanding of the hydrogen atom
- understand the basic properties of nuclei
- know the fundamental particles and interactions

Content
I. Introduction
II. Special relativity
III. Wave-particle duality
IV. Mater waves
V. The hydrogen atom VI. Nuclei and particles

Literature
Paul A. Tipler: Physics for engineers and scientists
Paul A. Tipler: Modern Physics

Course: Engine Laboratory [2134001]

Coordinators: U. Wagner
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
written documentation of every experiment, certificate of successful attendance, no grading

Conditions
none

Learning Outcomes
The students are abele to transfer their theoretical knowledge to practical problems and to perform engine tests on stat-of-the-art test benches.

Content
4 engine experiments in up-to-date development projects

Literature
Description of experiments

Remarks
max. 48 Participants

Course: Engine measurement techniques [2134137]

Coordinators: S. Bernhardt
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination, Duration: 0,5 hours, no auxiliary means

Conditions
None.

Recommendations
Combustion Engines I helpful

Learning Outcomes
The students are able to explain the principles of modern measuring devices and are able to determin the right device for a certain measuring problem. The are able to analyse and evaluate the results.

Content
Students get to know state-of-the-art measurement techniques for combustion engines. In particular basic techniques for measuring engine operating parameters such as torque, speed, power and temperature.

Possible measurement errors and abberations are discussed.

Furthermore techniques for measuring exhaust emissions, air/fuel ratio, fuel consumption as well as pressure indication for thermodynamic analysis are covered.

Literature
1. Grohe, H.:Messen an Verbrennungsmotoren
2. Bosch: Handbuch Kraftfahrzeugtechnik
3. Veröffentlichungen von Firmen aus der Meßtechnik
4. Hoffmann, Handbuch der Meßtechnik
5. Klingenberg, Automobil-Meßtechnik, Band C

Course: Nanoscale Systems for Optoelectronics [23716]

Coordinators: H. Eisler
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	en

Learning Control / Examinations
Oral exam

Conditions
Optics, Solid State Physics

Learning Outcomes
Bridging the EE Education towards quantum confined materials systems, fundamentals and applications as prototype and serial devices, such as quantum dot Smart TV screens, quantum dot PV, quantum dot single photon sources

Content
Interaction of Light with Nanoscale Systems
- general introdcution and motivation
- artificial quantum structures (semiconductor quantum dots, quantum wires...)
- quantum dot lasers, quantum dot-LED, quantum materials solar cells, single photon sources
Optical Interactions between Nanoscale Systems
- Förster energy transfer (dipole-dipole interaction)
- super-emitter concept
- SERS (surface enhanced Raman spectroscopy: bio-sensors)

Literature

- Principles of Nano-Optics, L. Novotny and B. Hecht, Cambridge University Press, 2006
- Absorption and Scattering of Light by Small Particles, C. F. Bohren and D. R. Huffman, John Wiley& Sons, INC. 1998
- Principles of Optics, Born and Wolf, Cambridge Univ

Remarks
You will find the newest Information online on https://studium.kit.edu/

Course: Nanotechnology for Engineers and Natural Scientists [2142861]

Coordinators: H. Hölscher, M. Dienwiebel, S. Walheim
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations

Conditions

None.

Learning Outcomes

Content

Literature

Ausgewählte Kapitel aus

- E. L. Wolf: Nanophysik und Nanotechnologie – Eine Einführung in die Konzepte der Nanowissenschaften, Wiley-VCH (2015)
- W. Kulisch: Nanotechnologie fur Einsteiger – Herstellung und Eigenschaften von Kohlenstoff-Nanostrukturen, Wiley-VCH (2016)
- D. Natelson: Nanostructures and Nanotechnology, Cambridge University Press (2016)

Weitere Originalliteratur wird über ILIAS zur Verfügung gestellt.

Course: Nanotechnology with Clusterbeams [2143876]

Coordinators: J. Gspann
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
written examination
presence in more that 70% of the lectures
Duration: 1 h

aids: none

Conditions
None.

Learning Outcomes
Nanotechnology is presented on the basis of a technology for nano- and microstructuring by accelerated nanoparticles (clusters), mainly in view of nanomechanics.

Content
Nanotechnology in biology
Nanosystemstechnology
Cluster beam generation, ionisation and acceleration; cluster properties
Structure generation using accelerated metal clusters
Structuring via gas cluster impact; reactive accelerated cluster erosion (RACE)
Atomic force microscopy of impact structures; nanotribology
Comparison with femtosecond laser machining (Winter term only)
Simulations; Fullerene synthesis, impact structures, visionary nanomachinery

Literature
Foil copies with short commentaries are distributed during the lectures.

Course: Nanotribology and -Mechanics [2182712]

Coordinators: M. Dienwiebel
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
presentation (40%) and oral examination (30 min, 60%)

no tools or reference materials

Conditions
preliminary knowlegde in mathematics and physics

Learning Outcomes
The student can

- explain the physical foundations and common models used in the field of nanotribology and nanomechanics
- describe the most important experimental methods in nanotribology
- critically evaluate scientific papers on nanotribological issues with respect to their substantial quality

Content
Part 1: Basics:

- Nanotechnology
- Forces at nanometer scale
- contact mechanics models (Hertz, JKR, DMT)
- Experimental methods (SFA, QCM, FFM)
- Prandtl-Tomlinson model
- Superlubricity
- Atomic-Scale Wear

Part 2: Topical papers

Literature
Edward L. Wolf
Nanophysics and Nanotechnology, Wiley-VCH, 2006
C. Mathew Mate
Tribology on the Small Scale: A Bottom Up Approach to Friction, Lubrication, and Wear (Mesoscopic Physics and Nanotechnology) 1st Edition, Oxford University Press
Lecture notes, slides and copies of articles

Course: Novel actuators and sensors [2141865]

Coordinators: M. Kohl, M. Sommer

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
(1) as core subject in the major “Microactuators and Microsensors” combined with the core subject “Micro Actuators”, oral, 60 minutes
or
(2) as elective subject in the other major fields, written exam
or
(3) as optional subject, written exam

Conditions
None.

Learning Outcomes
- Knowledge of the principles of actuation and sensing including pros and cons
- Explanation of layout and function of important actuators and sensors
- Calculation of important properties (time constants, forces, displacements, sensitivity, etc.)
- Development of a layout based on specifications

Content
Contents: - Basic knowledge in the material science of actuator and sensor principles
- Layout and design optimization
- Fabrication technologies
- Selected developments
- Applications

Index: The lecture includes amongst others the following topics:

- Piezo actuators
- Magnetostrictive actuators
- Shape memory actuators
- Electro-/magnetorheological actuators
- Sensors: Concepts, materials, fabrication
- Micromechanical sensors: Pressure, force, inertia sensors
- Temperature sensors
- Micro sensors for bio analytics
- Mechano-magnetic sensors

The lecture addresses students in the fields of mechanical engineering, mechatronics and information technology, materials science and engineering, electrical engineering and economic sciences. A comprehensive introduction is given in the basics and current developments on the macroscopic length scale.
The lecture is core subject of the major course “Actuators and Sensors” of the specialization “Mechatronics and Microsystems Technology” in Mechanical Engineering.

Literature
- Lecture notes
- Donald J. Leo, Engineering Analysis of Smart Material Systems, John Wiley & Sons, Inc., 2007
- „Sensors Update“, Edited by H.Baltes, W. Göpel, J. Hesse, VCH, 1996, ISBN: 3-527-29432-5
- “Multivariate Datenanalyse – Methodik und Anwendungen in der Chemie”, R. Henrion, G. Henrion, Springer 1994, ISBN 3-540-58188-X

Course: Neurovascular Interventions (BioMEMS V) [2141103]

Coordinators: A. Guber, G. Cattaneo
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination

Conditions
none

Learning Outcomes
Within the lecture, biomedical applications for neurovascular intervention are presented. In this biomedical field the use of microstructures and microsystems in the manufacturing of implants, devices and catheters allows for minimalinvasive treatments of the brain under challenging physiological and anatomical conditions.

Content
In the field of biomedical engineering for brain treatment, high requirements are placed on miniaturization, wherefore microstructure techniques play a crucial role in design and manufacturing
In the first part of the lecture, the anatomical and physiological background of the brain circulation as soon as the medical field of stroke and the imaging techniques for endovascular navigation are presented.
Catheter-based systems for the prevention of brain bleeding and reopening of occluded vessels are illustrated in the second part of the lesson. Influence of microcatheters and self expandable implants design and manufacturing on mechanical and biological behavior is analyzed and explained with the aid of application examples and samples.

Media
Lecture script

Course: Neutron physics of fusion reactors [2189473]

Coordinators: U. Fischer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes
The aim of this lecture is to provide the neutron physics principles required for analysis of nuclear fission and fusion reactors. First of all, the basic nuclear interaction processes are presented which are important for the physical behaviour of the reactors. Next the neutron transport phenomenon in matter is described by means of the Boltzmann transport equation. Suitable mathematical solution methods are presented such as the diffusion approximation for nuclear fission reactors and the Monte Carlo method for fusion reactors. The knowledge acquired will eventually be used to solve neutron physics problems related to the design and optimization of the reactors.

Content
Nuclear interaction processes and energy release

Chain reaction and criticality

Neutron transport, Boltzmann equation

Diffusion approximation, Monte Carlo method

Neutronic reactor design

Literature
K. H. Beckurts, K. Wirtz, Neutron Physics, Springer Verlag, Berlin, Germany (1964)

W. M. Stacey, Nuclear Reactor Physics, John Wiley & Sons, Wiley-VCH, Berlin(2007)

J. Raeder (Ed.), Kontrollierte Kernfusion. Grundlagen ihrer Nutzung zur Energieversorgung, Teubner, Stuttgart (1981)

Course: Nonlinear Continuum Mechanics [2162344]

Coordinators: T. Böhlke
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
5	2	Summer term	en

Learning Control / Examinations
oral examination

Conditions
None.

Recommendations
This course is geared to MSc students.

Learning Outcomes
The students can

- derive the kinematics of finite deformations
- derive the balance laws in regular and irregular points
- discuss the principles of material theory for given examples
- evaluate the basics of fihite elasticity
- discuss the basics of elasto-plasticity
- apply basic concepts of crystal plasticity to example problems

Content

- tensor calculus, kinematics, balance equations
- principles of material theory
- finite elasticity
- infinitesimal elasto(visco)plasticity
- exact solutions ov infinitesimal Platicity
- finite elasto(visco)plasticity
- infinitesimal and finite crystal(visco)plasticity
- hardening and failure
- strain localization

Literature
lecture notes
Bertram, A.: Elasticity and Plasticity of Large Deformations - an Introduction. Springer 2005.
Liu, I-S.: Continuum Mechanics. Springer 2002.
Schade, H.: Tensoranalysis.Walter de Gruyter 1997.
Wriggers, P.: Nichtlineare Finite-Element-Methoden. Springer 2001.

Course: Nuclear Fusion Technology [2189920]

Coordinators: A. Badea
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
written exam, graded, 60 min

Conditions
None.

Recommendations
good level of knowledge in physics and mathematics

Learning Outcomes
This lecture is dedicated to Master students of mechanical engineering and other engineering studies. Goal of the lecture is the understanding of the physics of fusion, the components of a fusion reactor and their functions. The technological requirements for using fusion technology for future commercial production of electricity and the related environmental impact are also addressed. The students are capable of giving technical assessment of the usage of the fusion energy with respect to its safety and sustainability.

Content
nuclear fission & fusion
neutronics for fusion
fuel cycles, cross sections
gravitational, magnetic and inertial confinement
fusion experimental devices
energy balance for fusion systems; Lawson criterion and Q-factor
materials for fusion reactors
plasma physics, confinement
plasma heating
timeline of the fusion technology
ITER, DEMO
safety and waste management

Course: Nuclear Power and Reactor Technology [2189921]

Coordinators: A. Badea
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
written exam, graded, 80 min

Conditions
None.

Recommendations
numerical methods, partial differential equations, special functions, orthogonal polynomials

Learning Outcomes
This lecture is dedicated to Master students of mechanical engineering and other engineering studies. Goal of the lecture is the understanding of reactor technology and of the major physical processes in converting nuclear power into electrical energy. Present and future nuclear systems (including reactors of the generation IV) are addressed. The students are capable of understanding the advantages and disadvantages of different reactor technologies by using the delivered knowledge on reactor physics, thermal-hydraulics, reactor design, control, safety and requirements of the front-end and back-end of the fuel cycle.

Content
nuclear fission & fusion,
chain reactions,
moderation,
light-water reactors,
transport- and diffusion-equation,
power distributions in reactor,
reactor safety,
reactor dynamics,
design of nuclear reactors,
breeding processes,
nuclear power systems of generation IV

Course: Numerical Mathematics [0187400]

Coordinators: C. Wieners, D. Weiß, Neuß, Rieder

Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Mathematical Methods (p. 32)[MSc-Modul 08, MM]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	de

Learning Control / Examinations
Written examination, duration 3 hours

Conditions
None.

Learning Outcomes

Content

Literature
Elective literature:
- lecture notes (D. Weiß)
- W. Dahmen/A. Reusken: Numerik für Ingenieure und Naturwissenschaftler

Course: Numerical mechanics for industrial applications [2162298]

Coordinators: E. Schnack
Part of the modules: Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
Oral examination. Duration: 20 minutes.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can name variation principles on the basis of the principles of virtual work and apply them to new algorithms. On this basis, students derive algorithms for higher-grade finite element processes (p-version of the finite element method (FEM)). Later on, students are able to describe the boundary element method (BEM) – the method competing with FEM – and characterize its advantages and drawbacks in comparison to FEM. In an exemplary application of BEM, students consider the Cauchy principal values and determine singular integrals of the integral equation that is the basis of BEM. In addition, the students extend the derived methods in order to deal with nonlinear problems of mechanical engineering (e.g. plasticity). At the end of the course, students are able to independently derive algorithms for FEM and BEM and to test short codes to better handle the existing industrial software.
Note: The "Introduction to Numerical Mechanics" is no prerequisite for participation in this course.
The lecture notes are made available via ILIAS.

Content
Brief overview of finite element methods. Structure of boundary element methods (BEM). Explanation of hybrid tension methods. Higher-grade finite element processes. Non-linear FEM processes.

Course: Numerical Modeling of Multiphase Flows [2130934]

Coordinators: M. Wörner
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination (in German or English language)
Duration: 30 minutes
Auxiliary means: none

Conditions
Bachelor

Learning Outcomes
The students can describe the physical fundamentals of multiphase flows (with focus on gas-liquid flows). The students are qualified to select for multiphase flow applications in energy and process engineering appropriate numerical methods and physical models, and to thoroughly evaluate the simulation results, so as to anaylze the specific advantages, disadvantages and restrictions of each method.

Content

1. Introduction in the subject of multi-phase flows (terms and definitions, examples)
2. Physical fundamentals (dimensionless numbers, phenomenology of single bubbles, conditions at fluid interfaces, forces on a suspended particle)
3. Mathematical fundamentals (governing equations, averaging, closure problem)
4. Numerical fundamentals (discretization in space and time, truncation error and numerical diffusion)
5. Models for interpenetrating continua (homogeneous model, algebraic slip model, standard two-fluid model and its extensions)
6. Euler-Lagrange model (particle equation of motion, particle response time, one-/two-/four-way coupling)
7. Interface resolving methods (volume-of-fluid, level-set and front-capturing method)

Literature
A brief script can be downloaded from http://bibliothek.fzk.de/zb/berichte/FZKA6932.pdf. Powerpoint presentations can be downloaded after each lecture from the ILIAS system. A list of recommended books is provided in the first lecture.

Remarks
For some topics of the lecture exercises are provided (working on them is optional).

Course: Numerical simulation of reacting two phase flows [2169458]

Coordinators: R. Koch
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam
Duration: approximately 30 minutes

no tools or reference materials are allowed

Conditions
None.

Recommendations
None.

Learning Outcomes
The students have the ability to:

- describe and apply the governing equations of fluid mechanics
- select and judge appropriate methods for predicting turbulent flows
- explain the procedures of numerical solver algorithms
- judge the numerical methods, on which comon CFD software is based
- judge and apply different approaches to characterize sprays
- apply methods for predicting the break up of liquids
- analyse and evaluate methods and models for the calculation of mulitphase flows
- describe reactive flows and the corresponding models

Content
The course is devoted to diploma/master students and doctoral candidates of mechanical and chemical engineering. It gives an overview of the numerical methods used for CFD of single and two phase flows. The course introduces methods for reacting single and two phase flows, as they are typically found in gas turbines and piston engines operated by liquid fuel.
1. Single phase flow: Basic equations of fluid dynamics, Turbulence: DNS, LES, RANS; Finite volume methods, Numerical solvers.

2. Two phase flows: Basics of atomisation, Characterisation of sprays, Numerical prediction of droplet movement, Numerical methods for predicitng of liquid disintegration (VoF, SPH), Numerical methods for secondary atomisation; Droplet evaporation

3. Reacting flows: Combustion models; Single droplet combustion, Spray combustion.

Literature
Lecture notes

Course: Numerical Simulation of Turbulent Flows [2153449]

Coordinators: G. Grötzbach
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral;

Duration: 30 minutes

no auxiliary means

Conditions
None.

Recommendations
basics in fluid mechanics

Learning Outcomes
The students are qualified to describe the fundamentals of direct numerical simulation (DNS) and large eddy simulation (LES) of turbulent flows. They understand the principle differences between these simulation methods and the respective properties of the conventional turbulence modelling approaches basing on Reynolds Averaged Navier-Stokes equations (RANS). They can describe subgrid scale models, peculiarities of wall and inlet/outlet modelling, suitable numerical solution schemes and evaluation methods. They have obtained the knowledge and understanding required to identify the best modelling approach (among the available methods) for the problem at hand, thus being able to solve given thermal and fluid dynamical problems appropriately.

Content
The lecture series will introduce in following subjects of the turbulence simulation method:

- Appearance of turbulence and deduction of requirements and limits of the simulation method.
- Conservation equations for flows with heat transfer, filtering them in time or space.
- Some subgrid scale models for small scale turbulence and their physical justification.
- Peculiarities in applying boundary and initial conditions.
- Suitable numerical schemes for integration in space and time.
- Statistical and graphical methods to analyse the simulation results.
- Application examples for turbulence simulations in research and engineering

Media
black board, plus pictures, movies, and script in English (distributed chapter by chapter)

Literature
J. Piquet, *Turbulent Flows – Models and Physics*
Springer, Berlin (2001)
G. Grötzbach, *Revisiting the Resolution Requirements for Turbulence Simulations in Nuclear Heat Transfer.*
Nuclear Engineering & Design Vol. 241 (2011) pp. 4379-4390
P. Sagaut, C. Meneveau, *Large-eddy simulation for incompressible flows: An introduction.*
Springer Verlag (2010)
G. Grötzbach,Script in English

Course: Numerical Fluid Mechanics [2153441]

Coordinators: F. Magagnato
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination
Duration: 30 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Learning Outcomes
The students can describe the modern numerical simulation methods for fluid flows and can explain their relevance for industrial projects. They can choose appropriate boundary and initial conditions as well as turbulence models. They are qualified to explain the meaning of suitable meshes for processed examples. Convergence acceleration techniques like multi grid, implicit methods etc. as well as the applicability of these methods to parallel and vector computing can be described by the students. They can identify problems that occur during application of these methods and can discuss strategies to avoid them. The students are qualified to become acquainted do use commercial codes like Fluent, Star-CD, CFX etc. as well as the research code SPARC. They can describe the differences between conventional methods (RANS) and more advanced approaches like Large Eddy Simulation (LES) and Direct Numerical Simulation (DNS).

Content
1. Governing Equations of Fluid Dynamics
2. Discretization
3. Boundary and Initial conditions
4. Turbulence Modelling
5. Mesh Generation
6. Numerical Methods
7. LES, DNS and Lattice Gas Methods
8. Pre- and Postprocessing
9. Examples of Numerical Methods for Industrial Applications

Media
"Powerpoint presentation", Beamer

Literature
Ferziger, Peric: Computational Methods for Fluid Dynamics. Springer-Verlag, 1999.
Hirsch: Numerical Computation of Internal and External Flows. John Wiley & Sons Inc., 1997.
Versteg, Malalasekera: An introduction to computational fluid dynamics. The finite volume method. John Wiley & Sons Inc., 1995

Course: Public Law I - Basic Principles [24016]

Coordinators: G. Sydow
Part of the modules: Compulsory Elective Module Economics/Law (p. 45)[MSc-Modul 12, WF WR]

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

Learning Control / Examinations
The assessment consists of a written exam concerning the courses *Public Law I* [24016] and *Public Law II* [24520] (according to Section 4(2), 1 of the examination regulation).

Conditions
None.

Recommendations
Parallel to the lectures tutoria are offered in which legal thinking and argumentation is practised. Their attendance is strongly recommended.
During the semester, test exams to each lecture are offered with extensive coaching. During the lecture-free time, a Q-and-A-lecture is offered.Details on the homepage of the ZAR (www.kit.edu/zar).

Learning Outcomes
The students know the core principles of public law. They are acquainted with the basics of constitutional law, the fundamental rights which route governmental actions and the entire legal system, as well as possibilities of actions and instruments (especially law, administrative act, public-private contract) of the public authority. Furthermore the distinction between public and private law is clarified. Moreover, possibilities of legal protection regarding administrative behavior is addressed. Students know how to classify problems in public law and to solve (simple) administrative and constitutional cases.

Content
The course covers core material of constitutional and administrative law. It begins with the differentiation between public and private law. In the constitutional law part, the course will concentrate on the rule of law and individual rights, especially those protecting communication and entrepreneurship. The administrative law part will explain the different legal instruments of the administration how to act (rule, order, contract, etc.) and their propositions. Also, court proceedings to sue the administrative will be discussed. Students will learn the technique how to solve (simple) administrative and constitutional cases

Media
extensive script with cases; content structure, further information in the lectures

Literature
tba in srciptum
Elective literature:
tba in scriptum

Course: Intellectual Property Rights and Strategies in Industrial Companies [2147161]

Coordinators: F. Zacharias
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The students understand and are able to describe the basics of intellectual property, particularly with regard to the filing and obtaining of property rights. They can name the criteria of project-integrated intellectual property management and strategic patenting in innovative companies. Students are also able to describe the key regulations of the law regarding employee invention and to illustrate the challenges of intellectual properties with reference to examples.

Content
The lecture will describe the requirements to be fulfilled and how protection is obtained for patents, design rights and trademarks, with a particular focus on Germany, Europe and the EU. Active, project-integrated intellectual property management and the use of strategic patenting by technologically oriented companies will also be discussed. Furthermore, the significance of innovations and intellectual property for both business and industry will be demonstrated using practical examples, before going on to consider the international challenges posed by intellectual property and current trends in the sector.
Within the context of licensing and infringement, insight will be provided as to the relevance of communication, professional negotiations and dispute resolution procedures, such as mediation for example. The final item on the agenda will cover those aspects of corporate law that are relevant to intellectual property.
Lecture overview:

1. Introduction to intellectual property
2. The profession of the patent attorney
3. Filing and obtaining intellectual property rights
4. Patent literature as a source of knowledge and information
5. The law regarding employee inventions
6. Active, project-integrated intellectual property management
7. Strategic patenting
8. The significance of intellectual property
9. International challenges and trends
10. Professional negotiations and dispute resolution procedures
11. Aspects of corporate law

Course: Patent Law [24656]

Coordinators: P. Bittner
Part of the modules: Compulsory Elective Module Economics/Law (p. 45)[MSc-Modul 12, WF WR]

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

Learning Control / Examinations
Written or oral examen.

Conditions
None.

Learning Outcomes
It is the aim of this course to provide students with knowledge in the area of patent law and the business of technical intellectual property that builds upon, and goes beyond the knowledge the students have already acquired in the general lecture of *Industrial and intellectual property law*. Students shall understand how the legal rules depend upon, and interact with, the economic background and the legislative policy in the field of technical intellectual property, particularly in the field of information and communication technologies. Students shall learn about the rules of national, European and international patent law as well as know-how protection law and to apply these legal rules in practical cases, in particular in the area of utilizing technical intellectual property through agreements and lawsuits. The conflict between the monopoly of a patent and the antitrust law policies in Europe will be reviewed with the students.

Content
The course deals with the subject matter of the law of technical intellectual property, in particular inventions, patents, utility models, design patents, know-how, the rights and obligations of employees as creators of technical IP, licensing, limitations and exceptions to patenting, term of protection, enforcement of the rights and defence against these in invalidation and revocation actions. The course does not merely focus on German patent law, but likewise puts European, US and international patent law into perspective. Students shall understand how the legal rules depend upon, and interact with, the economic background and the legislative policy in the field of technical intellectual property, particularly in the field of information and communication technologies. Students shall learn about the rules of national, European and international patent law as well as know-how protection law and to apply these legal rules in practical cases, in particular in the area of utilizing technical intellectual property through agreements and lawsuits. The conflict between the monopolyöf a patent and the antitrust law policies in Europe will be reviewed with the students.

Media
transparancies

Literature

- Schulte, Rainer Patentgesetz Carl Heymanns Verlag, 7. Aufl. 2005 ISBN 3-452-25114-4
- Kraßer, Rudolf, Patentrecht Verlag C.H. Beck, 5. Aufl. 2004 ISBN 3-406-384552

Elective literature:
tba in the transparencies

Course: Photovoltaics [23737]

Coordinators: M. Powalla
Part of the modules: Compulsory Elective Module Natural Science/Computer Science/Electrical Engineering (p. 44)[MSc-Modul 11, WF NIE]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	

Learning Control / Examinations
Turorials, written exams, alternatively oral exam.

Conditions
Basic knowledge of thermodynamics and solid state physics.

Recommendations
Complement to “Energy Systems” and “Fundamentals of Energy Technology”.

Learning Outcomes
After the course attendants can:

- understand energy conversion in semiconductors.
- discuss emerging technological and production relevant aspects.
- capture the interaction of photovoltaic energy sytems with different system components.
- quantify losses.

Content

- The significance of photovoltaics in national and global energy supply.
- Physical fundamentals of energy conversion.
- Photovoltaic cells (specific parameters, materials, loss assessment).
- Implementation concepts (Sillicon technology, thin layer cells, concentrator cells, dye cells and organic cells).
- Modular technique and production technology.
- Photovoltaic energy systems (Components, alternative current converter, solar tracking, system design).

Literature
P. Würfel, Physik der Solarzellen, 2. Auflage (Spektrum Akademischer Verlag, Heidelberg, 2000)
R. Sauer, Halbleiterphysik, (Oldenburg Wissenschaftsverlag, 2009)
H.J. Lewerenz, H. Jungblut, Photovoltaik (Springer, Berlin, 1995)
H.G. Wagemann, Photovototaik, (Vieweg, Wiebaden, 2010)
Tom Markvart, Luis Castaner, Photovoltaics Fundamentals and Applications, (Elsevier, Oxford, 2003)
Heinrich Häberlin, Photovoltaik, (AZ Verlag, Aarau, 2007)

Course: Physics for Engineers [2142890]

Coordinators: P. Gumbsch, A. Nesterov-Müller, D. Weygand, T. Förtsch

Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

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

Learning Control / Examinations
written exam, 90 min

Conditions
none

Learning Outcomes
The student

- has the basic understanding of the physical foundations to explain the relationship between the quantum mechanical principles and the optical as well as electrical properties of materials
- can describe the fundamental experiments, which allow the illustration of these principles

Content
1) Foundations of solid state physics

- Wave particle dualism
- Tunnelling
- Schrödinger equation
- H-atom
- bonding between atoms

2) Electrical conductivity of solids

- solid state: periodic potentials
- Pauli Principle
- band structure
- metals, semiconductors and isolators
- p-n junction / diode
- superconductivity

3) Optics

- quantum mechanical principles of the laser
- linear optics
- non-linear optics

- quantum optics

Exercises (2142891, 2 SWS) are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students and for testing progress in learning of the topics.

Literature

- Tipler und Mosca: Physik für Wissenschaftler und Ingenieure, Elsevier, 2004
- Haken und Wolf: Atom- und Quantenphysik. Einführung in die experimentellen und theoretischen Grundlagen, 7. Aufl., Springer, 2000
- Harris, Moderne Physik, Pearson Verlag, 2013

Course: Physical basics of laser technology [2181612]

Coordinators: J. Schneider

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Compulsory Elective Module Natural Science/Computer Science/Electrical Engineering (p. 44)[MSc-Modul 11, WF NIE], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
The assessment consists of an oral exam (ca. 30 min) taking place at the agreed date (according to Section 4(2), 2 of the examination regulation). The re-examination is offered upon agreement.

no tools or reference materials

Conditions
It is allowed to select only one of the lectures "Laser in automotive engineering" (2182642) or "Physical basics of laser technology" (2181612) during the Bachelor and Master studies.

Recommendations
Basic knowledge of physics, chemistry and material science is assumed.

Learning Outcomes
The student

- can explain the principles of light generation, the conditions for light amplification as well as the basic structure and function of different laser sources.
- can describe the influence of laser, material and process parameters for the most important methods of laser-based materials processing and choose laser sources suitable for specific applications.
- can illustrate the possible applications of laser sources in measurement and medicine technology
- can explain the requirements for safe handling of laser radiation and for the design of safe laser systems.

Content
Based on the description of the physical basics about the formation and the properties of laser light the lecture goes through the different types of laser beam sources used in industry these days. The lecture focuses on the usage of lasers especially in materials engineering. Other areas like measurement technology or medical applications are also mentioned. An excursion to the laser laboratory of the Institute for Applied Materials (IAM) will be offered.

- physical basics of laser technology
- laser beam sources (solid state, diode, gas, liquid and other lasers)
- beam properties, guiding and shaping
- lasers in materials processing
- lasers in measurement technology
- lasers for medical applications
- savety aspects

The lecture is complemented by a tutorial.

Media
lecture notes via ILIAS

Literature
W. T. Silfvast: Laser Fundamentals, 2008, Cambridge University Press
W. M. Steen: Laser Material Processing, 2010, Springer

Remarks
It is allowed to select only one of the lectures "Laser in automotive engineering" (2182642) or "Physical basics of laser technology" (2181612) during the Bachelor and Master studies.

Course: Planning of Assembly Systems (in German) [2109034]

Coordinators: E. Haller
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Elective Subject: oral exam (approx. 30 min)
Optional Subject: oral exam (approx. 30 min)
The exam is offered in German only!

Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required
- Compulsory attendance during the whole lecture

Recommendations

- Knowledge of Human Factors Engineering or Production Management/Industrial Engineering helpful

Learning Outcomes
The students

- know planning guidelines
- know vulnerability analysis
- are able to plan work systems (e.g. technical or organisational structuring principles, capacity planinng, proceedence diagram, payment system)
- are able to evaluate a planning solution
- are able to present results

Content

1. Planning guidelines
2. Vulnerability analysis
3. Planning of work systems (technical and organisational structuring principles, capacity planning, proceedence diagram, payment system)
4. Evaluation
5. Presentation

Literature
Handout and literature online ILIAS.

Course: Multi-scale Plasticity [2181750]

Coordinators: K. Schulz, C. Greiner
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
presentation (40%), oral examination (30 min, 60%)

Conditions

- limited number of participants
- mandatory registration
- mandatory attendance

Recommendations
preliminary knowlegde in mathematics, physics, mechanics and materials science

Learning Outcomes
The student

- can explain the physical foundations of plasticity as well as results of latest research.
- can independently read and evaluate scientific research papers.
- can present specific, technical information in structured, precise, and readable manner.
- is able to argue for and/or against a particular approach or idea using the knowledge acquired within the lecture.

Content
This module will attempt to provide an overview to complex subjects in the field of material mechanics. For this purpose important scientific papers will be presented and discussed.
This will be done by having students read and critique one paper each week in a short review. In addition, each week will include presentation from one of the participants which aim to advocate or criticise each piece of work using the short reviews. He will also be the discussion leader, while students discuss the content, ideas, evaluation and open research questions of the paper. Using a professional conference management system (HotCRP), the student assume the role of reviewers and gain insight into the work of researchers.

Media
black board, beamer, script

Remarks
The maximum number of students is 14 per semester.

Course: PLM for Product Development in Mechatronics [2122376]

Coordinators: M. Eigner
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam (30 min.).

Conditions
None.

Learning Outcomes
Students have a basic overview about product data management and product lifecycle management.
Students know components and core functions of PLM solutions
Students can describe trends in research and practice in the environment of PLM

Content
Product Data Management
Product Lifecycle Management

Course: PLM in the Manufacturing Industry [2121366]

Coordinators: G. Meier
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral group examination, Duration 1 hour, Auxiliary Means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
Students know essential aspects of PLM Processes which are exemplarily introduced with examples form Heidelberger Druckmaschinen.
Students know objects of the PLM Process and know the interconnection between CAD and PLM.
Students understand the procedure of PLM-installation in an industrial enterprise and occurring challenges concerning strategy, vendor selection and psychology.
They are able to create installation concepts for PLM systems in the scope of team exercises and explain the approaches in presentations.

Content
A description of systematic requirement engineering is given, based on the introduction of PLM-Processes and (Multi-) Project management in the product development process. By the introduction of a PLM-Project, Objects of the PLM Process like material master, bill of material, documents and classifications are explained. Furthermore a 3D-Process chain is introduced to show the implementation of technical modifications. Finally, specific aspects of the mechatronic development are introduced.

Literature
Lecture slides

Course: Plug-and-play material handling [2117070]

Coordinators: K. Furmans, J. Dziedzitz
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
Presentation of the four steps of the course content (design, implementation, test concept and evaluation)

Conditions
presence obligatory

Recommendations
None

Learning Outcomes
Students are able to:

- discuss the theoretical background of plug-and-play material handling systems
- improve their knowledge in this field by individual literature search
- apply the theoretical basics learned in this course to solve practical problems
- use the software framework ROS (robot operating system)
- design parts for additive manufacturing (3D printing)
- judge their own practical solution by logistic key measures

Content

- Theoretical basics of structure of plug-and-play material handling systems
- Practical application of course contents (team work using a mobile platform)
- Design and implementation of a system control based on the software framework ROS
- Definition, design and construction of interfaces between the teams' individual systems
- Presentation of results and evaluation using logistic key measures

Media
Mobile platform, 3D printer, PC

Literature
none

Remarks
number of participants limited; participants will be selected.

Course: Polymer Engineering I [2173590]

Coordinators: P. Elsner
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
None.

Learning Outcomes
The field of Polymer Engineering includes synthesis, material science, processing, construction, design, tool engineering, production technology, surface engineering and recycling. The aim is, to equip the students with knowledge and technical skills, and to use the material "polymer" meeting its requirements in an economical and ecological way.
The students

- are able to describe and classify polymers
  based on the fundamental synthesis processing techniques
- can find practical applications for state-of-the-art polymers and manufacturing technologies
- are able to apply the processing techniques, the application of polymers and polymer composites regarding to the basic principles of material science
- can describe the special mechanical, chemical and elctrical prooperties of polymers and correlate these properties to the chemical bindings.
- can define application areas and the limitation in the use of polymers

Content
1. Economical aspects of polymers
2. Introductiom of mechanical,
chemical end electrical properties
3. Processing of polymers
(introduction)
4. Material science of polymers
5. Synthesis

Literature
Recommended literature and selected official lecture notes are provided in the lecture

Course: Polymer Engineering II [2174596]

Coordinators: P. Elsner
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
None.

Recommendations
Knowledge in Polymerengineering I

Learning Outcomes
The field of Polymer Engineering includes synthesis, material science, processing, construction, design, tool engineering, production technology, surface engineering and recycling. The aim is, that the students gather knowledge and technical skills to use the material "polymer" meeting its requirements in an economical and ecological way.
The students

- can describe and classify different processing techniques
  and can exemplify mould design principles based on technical parts.
- know about practical applications and processing of polymer parts
- are able to design polymer parts according to given restrictions
- can choose appropriate polymers based on the technical requirements
- can decide how to use polymers regarding the production, economical and ecological requirements

Content
1. Processing of polymers
2. Properties of polymer components
Based on practical examples and components
2.1 Selection of material
2.2 Component design
2.3 Tool engineering
2.4 Production technology
2.5 Surface engineering
2.6 Sustainability, recycling

Literature
Recommended literature and selected official lecture notes are provided in the lecture

Course: Polymers in MEMS A: Chemistry, Synthesis and Applications [2141853]

Coordinators: B. Rapp
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Bachelor students with basic knowledge in material science and chemistry. The lecture will cover all the basics required for understanding the organic chemistry so detailed previous knowledge is not required. Basic understanding of MEMS and its technologies is helpful but not mandatory.

Learning Outcomes
The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge required for understanding what polymers are and how they are made, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.
After attending the lecture the students will be able:

- . . . to understand the physic/chemical basics of organic chemistry in polymer synthesis.
- . . . to state the most important polymers and polymer classes and to develop application examples for these.
- . . . to state the most important polymers in MEMS.
- . . . to understand the most important techniques for rapid prototyping.
- . . . to state and to understand the most important resists in MEMS.
- . . . to understand the chemical synthesis of polymers.

. . . to correctly estimate the application scope of the individual classes of polymers.

Content
We all come in contact with numerous polymeric products in everyday life. From water bottles to packaging to the cover of the iPad, many things are made of polymers. Polymers are also important materials for modern microelectromechanical systems (MEMS) allowing cost effective mass market compatible products, e.g., in the life sciences or diagnostics. But polymers are not just cost-effective replacements for more expensive classical materials in MEMS (such as, e.g., silicon) – some polymers have intrinsic properties that make them ideal materials for sensors, actuators or templates for biology and chemistry in MEMS.
This lecture will introduce the basics of organic chemistry required for understanding what polymers are, how they are manufactured and which mechanisms are responsible for their unique properties. The lecture will highlight (in the context of MEMS but also in a wider scope) where and why polymers are applied with a strong focus on their chemical and physical properties (and on their synthesis).
Some of the topics covered are:

- What is the basic chemistry of polymers? What are monomers, what are macromolecules and how are they formed?
- How are polymers produced on industrial scale – but also on the laboratory scale? Numerous examples of how to make (commonly and lesser known) polymers will be discussed including materials such as Plexiglas.
- Why are polymers so important for biochemistry and tissue engineering?
- How do photoresists work and why do some polymers contract when exposed to light?
- What are high-performance polymers and why do they have such a wide application range, e.g., in implants?

- What polymers fuel the household 3D printing community and what materials do 3D printers such as, e.g., the RepRap work with?
- How does 3D printing and rapid prototyping work and which polymers can be employed for which techniques?
- Why does silicone always smell like vinegar and why is this material so important for modern day microfluidics? How do you built fluid-logic devices using silicone?
- How do shape memory polymers remember their shape?
- What are polymer foams and why are they not only important for heat insulation but also for organic chemistry?
- How do glues work? Why are there two-component glues, what is superglue and how can you make glue from potatoes?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.
For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu). Preregistration is not necessary.

Media
The lecture slides will be given out as scriptum during each lecture course.

Remarks
For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu). Preregistration is not necessary.

Course: Polymers in MEMS B: Physics, Microstructuring and Applications [2141854]

Coordinators: M. Worgull
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Bachelor students with basic knowledge in material science and mechanical engineering. The lecture will cover all the basics required for understanding. Detailed knowledge of microsystem technology and it's processes is helpful but not mandatory.

Learning Outcomes
The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge required for understanding what polymers are and how they are made, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.
After attending the lecture the students will be able:

- ... to understand the properties of polymers as a consequence of their morphology.
- ... to describe the most important structuring techniques and technologies for polymers in MEMS.
- ... to understand the mathematical basis of the most important physical models for polymers.
- ... to correctly judge polymer properties and the applicability of the polymers for their industrial processability.
- ... to understand the basics of process simulation in polymer structuring.
- ... to state the most important technical thermoplasts in MEMS and to understand their properties.
- ... to correctly classify the various types of polymers, blends, composite materials.

Content
We all come in contact with numerous polymeric products in everyday life. From water bottles to packaging to the cover of the iPad, many things are made of polymers. Polymers are also important materials for modern microelectromechanical systems (MEMS) allowing cost effective mass market compatible products, e.g., in the life sciences or diagnostics. But polymers are not just cost-effective replacements for more expensive classical materials in MEMS (such as, e.g., silicon) – some polymers have intrinsic properties that make them ideal materials for sensors, actuators or templates for biology and chemistry in MEMS.
This lecture will introduce the basics of physics and material science required for the understanding of the mechanical behavior seen from the engineers view. Micro and nanostructuring of polymers allows the fabrication of micro parts fulfilling their tasks in mostly invisible different applications. But also the fabrication of polymer parts with functional surfaces inspired from Bionics will be presented in this lesson. The lesson will give further an overview over the polymer based structuring processes and will underline the importance by a number of applications e.g. photonic structures or Lotus-like structures.
Some of the topics covered are:

- How can polymers described from the view of engineers?
- What are the differences between polymers and metals?
- Rheology of polymer melts – How does polymer melts flow?
- How can polymers be formed and demolded?
- Which structuring processes (replication) processes are available?

- How does stress influence molded parts (e.g. the deformation of a CD in a hot car)
- Shrinkage of polymers – which precision is achievable
- Gluing or welding – How can polymers be assembled?
- Simulation of replication processes
- Characterization of polymers – which properties can be measured?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.
For further details, please contact the lecturer, PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

Media
The lecture slides will be given out as scriptum during each lecture course.

Remarks
For further details, please contact the lecturer, PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

Course: [2142855]

Coordinators: M. Worgull, B. Rapp
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Bachelor students with basic knowledge in material science and chemistry. Basic understanding of MEMS and its technologies is helpful but not mandatory. Students should also have attended either “Polymers in MEMS A” or “Polymers in MEMS B” during winter semester as this lecture will not provide a general introduction in the chemistry of polymers or polymer processing.

Learning Outcomes
The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge of biopolymers and bioplastics, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.
After attending the lecture the students will be able:

- ... to correctly classify biopolymers and bioplastics.
- ... to correctly state their properties, advantages and disadvantages.
- ... to correctly estimate their application scope in MEMS.
- ... to understand their usage in everyday life.
- ... to correctly judge their sustainability.
- ... to develop further applications of this class of materials.

... to correctly estimate the suitability of biopolymers and bioplastics, especially compared to conventionally polymers.

Content
Polymers are ubiquitous in everyday life: from packaging materials all the way to specialty products in medicine and medical engineering. Today it is difficult to find a product which does not (at least in parts) consist of polymeric materials. The question of how these materials can be improved with respect to their disposal and consumption of (natural) resources during manufacturing is often raised. Today polymers must be fully recycled in Germany and many other countries due to the fact that they do not (or only very slowly) decompose in nature. Furthermore significant reductions of crude oil consumption during synthesis are of increasing importance in order to improve the sustainability of this class of materials. With respect to disposal polymers which do not have to be disposed by combustion but rather allow natural decomposition (composting) are of increasing interest. Polymers from renewable sources are also of interest for modern microelectromechanical systems (MEMS) especially if the systems designed are intended as single-use products.
This lecture will introduce the most important classes of these so-called biopolymers and bioplastics. It will also discuss and highlight polymers which are created from naturally created analogues (e.g. via fermentation) to petrochemical polymer precursors and describe their technical processing. Numerous examples from MEMS as well as everyday life will be given.
Some of the topics covered are:

- What are biopolyurethanes and how can you produce them from castor oil?
- What are “natural glues” and how are they different from chemical glues?
- How do you make tires from natural rubbers?

- What are the two most important polymers for life on earth?
- How can you make polymers from potatoes?
- Can wood be formed by injection molding?
- How do you make buttons from milk?
- Can you play music on biopolymers?
- Where and how do you use polymers for tissue engineering?
- How can you built LEGO with DNA?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.
For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu) and PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

Literature
Additional literature is not required.

Remarks
For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu) and PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

Course: Laboratory "Laser Materials Processing" [2183640]

Coordinators: J. Schneider, W. Pfleging
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
The assessment consists of a colloquium for every single experiment and an overall final colloquium incl. an oral presentation of 20 min.

Conditions
None.

Recommendations
Basic knowledge of physics, chemistry and material science is assumed.
The attendance to one of the courses Physical Basics of Laser Technology (2181612) or Laser Application in Automotive Engineering (2182642) is strongly recommended.

Learning Outcomes
The student

- can describe the influence of laser, material and process parameters and can choose suitable parameters for the most important methods of laser-based processing in automotive engineering.
- can explain the requirements for safe handling of laser radiation and for the design of safe laser systems.

Content
The laboratory compromises 8 half-day experiments, which address the following laser processing topics of metals, ceramics and polymers:
• safety aspects
• surface hardening and remelting
• melt and reactive cutting
• surface modification by dispersing or alloying
• welding
• surface texturing
• metrology
There are used CO_2-, excimer-, Nd:YAG- and high power diode-laser sources within the laboratory.

Media
lecture notes via ILIAS

Literature
W.T. Silfvast: Laser Fundamentals, 2008, Cambrigde University Press
W.M. Steen: Laser Materials Processing, 2010, Springer

Remarks
The maximum number of students is 12 per semester.

Course: Workshop on computer-based flow measurement techniques [2171488]

Coordinators: H. Bauer
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
Group colloquia for each topic

Duration: approximately 10 minutes

no tools or reference materials may be used

Conditions
none

Learning Outcomes
The students are able to:

- theoretically describe and explain the fundamentals of computer aided measurements and and adopt them practically
- apply the basics learned during the lecture to a practical problem in the form of a PC excercise

Content
The laboratory course offers an introduction into the acquisition of basic test data in fluid mechanics applications as well as a basic hands-on training for the application of modern PC based data acquisition methods. The combination of lectures about measurement techniques, sensors, signal converters, I/O systems, bus systems, data acquisition, handling and control routines and tutorials for typical fluid mechanics applications allows the participant to get a comprehensive insight and a sound knowledge in this field. The graphical programming environment LabVIEW from National Instruments is used in this course as it is one of the standard software tools for data acquisition worldwide.
Basic design of measurements systems

- Logging devices and sensors
- Analog to digital conversion
- Program design and programming methods using LabView
- Data handling
- Bus systems
- Design of a computer aided data acquisition system for pressure, temperature and derived parameters
- frequency analysis

Literature
Germer, H.; Wefers, N.: Meßelektronik, Bd. 1, 1985
LabView User Manual
Hoffmann, Jörg: Taschenbuch der Messtechnik, 6., aktualisierte. Aufl. , 2011

Course: Lab course experimental solid mechanics [2162275]

Coordinators: T. Böhlke, Mitarbeiter
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
attestation without grade

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can

- list basic measuring methods for thermoelasticity
- perform measurements for determining material parameters of thermoelasticity
- apply the concepts of parameter identification to experimentally obtained stress-strain-curves
- list and evalutate different forms of anisotropy

Content

- Anisotropic materials
- Experiments for determination of the five material constants of thermoelasticity
- Experiments for determination of parameters of the inelatic material behaviour

Literature
is announced during lab course

Course: Product Lifecycle Management [2121350]

Coordinators: J. Ovtcharova, T. Maier
Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

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

Learning Control / Examinations
written examination
Duration:
1,5 hours

Auxiliary Means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can:

- clarify the management concept of PLM, its objectives and highlight the economic benefits of the PLM concept.
- illustrate the need for an integrated and cross-departmental business process - from planning, portfolio construction and return of customer information, from the use phase to maintenance and recycling of products.
- reason the processes and functions needed to support the entire product life cycle and discuss the main operating software systems (PDM, ERP, SCM, CRM) and their functions for supporting PLM.
- argue a method to successfully introduce the concept of Management PLM in companys.

Content
Product Lifecycle Management (PLM) is an approach to the holistic and cross-company management and control of all product-related processes and data throughout the life cycle along the extended supply chain - from design and production to sales, to the dismantling and recycling.
Product Lifecycle Management is a comprehensive approach for effective and efficient design of the product life cycle. Based on all product information, which comes up across the entire value chain and across multiple partners, processes, methods and tools are made available to provide the right information at the right time, quality and the right place.
The course covers:

- A consistent description of all business processes that occur during the product life cycle (development, production, sales, dismantling, ...)
- the presentation of methods for the performance of the PLM business processes,
- explaining the most important corporate information systems to support the life cycle (PDM, ERP, SCM, CRM systems) to sample the software manufacturer SAP

Literature
Lecture slides.

V. Arnold et al: Product Lifecycle Management beherrschen, Springer-Verlag, Heidelberg, 2005.

J. Stark: Product Lifecycle Management, 21st Century Paradigm for Product Realisation, Springer-Verlag, London, 2006.

A. W. Scheer et al: Prozessorientiertes Product Lifecycle Management, Springer-Verlag, Berlin, 2006.

J. Schöttner: Produktdatenmanagement in der Fertigungsindustrie, Hanser-Verlag, München, 1999.

M.Eigner, R. Stelzer: Produktdaten Management-Systeme, Springer-Verlag, Berlin, 2001.

G. Hartmann: Product Lifecycle Management with SAP, Galileo press, 2007.

K. Obermann: CAD/CAM/PLM-Handbuch, 2004.

Course: Product, Process and Resource Integration in the Automotive Industry [2123364]

Coordinators: S. Mbang
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination, Durations: 20 min, Auxiliary Means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
A considerable aspect of this lecture is to combine engineering knowledge with the practical, real industrial problems and applications.
Thus, the objectives of the lecture are:

- collaborative drafting of industrial and academic state of the art regarding the basics.
- specification of exigencies, requirements and concepts for an integrated CAx-process chain,
- introduction in the paradigms of the integrated process-oriented product development
- to convey practical industrial knowledge about the integrated product development in the automotive sector

Content
The lecture

- Overview of product development in the automotive sector (process- and work cycle, IT-Systems)
- Integrated product models in the automotive industry (product, process and resource)
- New CAx modeling methods (intelligent feature technology, templates & functional modeling)
- Automation and knowledge-based mechanism for product design and production planning
- Product development in accordance with defined process and requirement (3D-master principle, tolerance models)
- Concurrent Engineering, shared working
- Enhanced concepts: the digital and virtual factory (application of virtual technologies and methods in the product development)
- Systems: CAD/CAM modeling (CATIA V5), planning (CATIA/DELMIA), archiving – PDM (CATIA/SmarTeam).

Additionally, A practical industrial project study is offered, which is based on an integrated application scenario (from design of production resources, over testing and validation method planning to the manufacturing and implementation of the production resources).
Since the student will be divided in small teams, this study will also teach the students about team word and distributed development.

Literature
Lecture slides

Remarks
Max. 20 students, registration necessary (ILIAS)

Course: Product Development - Dimensioning of Components [2150511]

Coordinators: V. Schulze, S. Dietrich
Part of the modules: Product Development - Dimensioning of Components (p. 28)[MSc-Modul, PE-B (2016)]

ECTS Credits	Hours per week	Term	Instruction language
7	3	Summer term	de

Learning Control / Examinations
written exam (2 hours)

Conditions
None

Recommendations
None

Learning Outcomes
The students. . .

- are capable to design and dimension components according to their load.
- can include mechanical material properties from the mechanical material test in the dimensioning process.
- can identify superimposed total loads and critical loads on simple components and to compute them.
- acquire the skill to select materials based on the application area of the components and respective loads.

Content
The aim of the lecture is to present the topics of the dimensioning and the material science in their connection and to learn how to deal with corresponding methods and the combination thereof.
For the prospective engineer the most important educational objective is to understand the interaction of these topics while the interplay of the individual material stresses in the component are clarified.

The topics in detail are

Structural dimensioning: basic stresses, superimposed stresses, notch influence, fatigue limit, fatigue strength, assessment of cracked components, operational strength, residual stresses, high temperature stress and corrosion

Material selection: Basics, material indices, material selection diagrams, Ashby procedure, multiple boundary conditions, target conflicts, shape and efficiency.

Media
Commented lectures slides will be accessible on Ilias

Literature
Lecture notes

Course: Production Planning and Control [2110032]

Coordinators: A. Rinn
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Elective Subject: oral exam (approx.. 30 min)
Optional Subject: oral exam (approx. 30 min)
The exam is offered in German only!

Conditions

- Compact course
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required
- Compulsory attendance during the whole lecture

Recommendations

- Knowledge in Production Management/Industrial Engineering is required
- Knowledge of Work Science and Economics is helpful
- Knowledge of Informatics is not required, but helpful

Learning Outcomes

- Gain deeper insight within production management
- Increase knowledge of production planning and control
- Understand realistic practical aspects
- Understand basic techniques for the modelling and the simulation of production systems

Content

1. Practical application of PPC-methods
2. Goals and recommanditions for production planning and control
3. Strategies for work control
4. Case study: Manufacturing of bicycles
5. Simulation of a bicycle factory for the production planning and control
6. Simulation of the order processing
7. Decision making about order control and procurement of purchased parts
8. Evaluation of the simulation protocols
9. Realisation of production planning and control

Literature
Handout and literature are available on ILIAS for download.

Course: Production Techniques Laboratory [2110678]

Coordinators: K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
Advanced Internship: Participate in practicle exercise courses and complete the colloquia successfully.
Elective Subject: Participate in practicle exercise courses and complete the colloquia successfully and presentation of a specific topic.
Optional Subject: Participate in practicle exercise courses and complete the colloquia successfully and presentation of a specific topic.

Conditions
None.

Recommendations
Participation in the following lectures:

- Informationssystems in logistics and supply chain management
- Material flow in logistic systems
- Manufacturing technology
- Human Factors Engineering

Learning Outcomes
The students acquire in the lab profound knowledge about the scientific theories, principles and methods of Production Engineering. Afterwards they are able to evaluate and design complex production systems according to problems of manufacturing and process technologies, materials handling, handling techniques, information engineering as well as production organisation and management.
After completion this lab, the students are able

- to analyse and solve planning and layout problems of the discussed fields,
- to evaluate and configure the quality and efficiency of production, processes and products,
- to plan, control and evaluate the production of a production enterprise,
- to configure and evaluate the IT architecture of a production enterprise,
- to design and evaluate appropriate techniques for conveying, handling and picking within a production system,
- to design and evaluate the part production and the assembly by considering the work processes and the work places.

Content
The production technique laboratory (PTL) is a collaboration of the institutes wbk, IFL, IMI and ifab.

1. Computer Aided Product Development (IMI)
2. Computer communication in factory (IMI)
3. Production of parts with CNC turning machines (wbk)
4. Controlling of production systems using PLCs (wbk)
5. Automated assembly systems (wbk)
6. Optical identification in production and logistics (IFL)

7. RFID identification systems (IFL)
8. Storage and order-picking systems (IFL)
9. Production Management (ifab)
10. Time study (ifab)
11. Accomplishment of workplace design (ifab)

Media
several

Literature
Handout and literature references are available online on ILIAS.

Remarks
none

Course: Productivity Management in Production Systems [2110046]

Coordinators: S. Stowasser
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Elective Subject: oral exam (approx. 30 min)
Optional Subject: oral exam (approx. 30 min)
The exam is offered in German only!

Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required
- Compulsory attendance during the whole lecture

Recommendations

- Knowledge of work science is helpful

Learning Outcomes

- Ability to design work operations and processes effecitvely and efficiently
- Instruction in methods of time study (MTM, Data acquisition etc.)
- Instruction in methods and principles of process design
- The Students are able to apply methods for the design of workplaces, work operations and processes.
- The Students are able to apply actual approaches of process and production organisation.

Content

1. Definition and terminology of process design and industrial engineering
2. Tasks of industrial engineering
3. Actual approaches of organisation of production (Holistic production systems, Guided group work et al.)
4. Methods and principles of industrial engineering and production systems
5. Case studies and exercises for process design

Media
Powerpoint, movies, exercises

Literature
Handout and literature is available on ILIAS for download.

Course: Project Workshop: Automotive Engineering [2115817]

Coordinators: F. Gauterin, M. Gießler, M. Frey
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Winter / Summer Term	de

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
None.

Learning Outcomes
The students are familiar with typical industrial development processes and working style. They are able to apply knowledge gained at the university to a practical task. They are able to analyze and to judge complex relations. They are ready to work self-dependently, to apply different development methods and to work on approaches to solve a problem, to develop practice-oriented products or processes.

Content
During the Project Workshop Automotive Engineering a team of six persons will work on a task given by an German industrial partner using the instruments of project management. The task is relevant for the actual business and the results are intended to be industrialized after the completion of the project workshop.

The team will generate approaches in its own responsibility and will develop solutions for practical application. Coaching will be supplied by both, company and institute.

At the beginning in a start-up meeting goals and structure of the project will be specified. During the project workshop there will be weekly team meetings. Also a milestone meeting will be held together with persons from the industrial company. In a final presentation the project results will be presented to the company management and to institute representatives.

Literature
Steinle, Claus; Bruch, Heike; Lawa, Dieter (Hrsg.), Projektmanagement, Instrument moderner Innovation, FAZ Verlag, Frankfurt a. M., 2001, ISBN 978-3929368277

The scripts will be supplied in the start-up meeting.

Remarks
Selection procedure, applications are to submit in the end of the preceding semester. The admission is limited to 6 persons per team.

Course: Project Mikro Manufacturing: Design and Manufacturing of Micro Systems [2149680]

Coordinators: V. Schulze, B. Matuschka, A. Kacaras
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
None

Recommendations
Knowledge of CAD tools is favorable but not necessary. Previous knowledge of manufacturing is reasonable.

Learning Outcomes
The students ...

- are able to describe the micro manufacturing processes as well as their characteristics and applications.
- can choose suitable manufacturing processes for a given product.
- are able to describe the process along the CAD-CAM process chain from scratch to manufacturing.
- can explain how the development process for a micro product looks like.
- are able to describe how design for manufacturability works for micro products and where the differences to macroscopic scale are.

Content
The course „Project micro manufacturing: design and manufacturing of a micro system“ combines the basics of micro manufacturing with project work. The project work will be done in cooperation with an industry partner. The students learn the basics of micro milling, micro electric discharge machining, micro laser ablation, micro powder injection molding and micro quality assurance. Furthermore they get to know the CAD-CAM process chain. That is the manufacturing of a production out of a CAD model. The students develop ideas and concepts matching the given task and present the results to the industry partner. Then they create parts that are designed for manufacturability out of their concepts. Those parts are manufactured at the wbk and finally assembled to a prototype. In winter semester 2012/13 innovative couplings for model railways were developed and functional prototypes were built.

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Development of Oil-Hydraulic Powertrain Systems [2113072]

Coordinators: G. Geerling, S. Becker
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

Conditions
None.

Recommendations
pre-knowledge in fluid mechanics

Learning Outcomes
The students are able to understand hydraulic systems und to develop them independently. They apply their competences in a simulation of a development project with real hydraulic components within a laboratory tutorial.

Content
The bloc course offered by the Chair of Mobile Machines (Mobima) conveys the basics of planning and development of mobile and industrial hydrostatic systems. The lecturer works for a market leading company producing fluid power drives and controls and gives a deep view into the process of planning and development using real life examples. The contents of the course are:

- marketing, project planning
- hydrostatic circuits
- heat balance, hydraulic accumulators
- filtration, noise lowering
- development exercises + laboratory tutorial

Course: Project Management in Rail Industry [2115995]

Coordinators: P. Gratzfeld
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
No tools or reference materials may be used during the exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students learn the basic of project management.
They learn about the roles of project manager and project core team.
They understand the project phases and know about processes and tools.
They understand the governance process behind.

Content
Rail vehicles are capital-intensive goods which are manufactured in small series (like aircraft). The work to done at industry and customers is organized in "projects". This is completely different to the way of working in large-scale production (like car industry). Everybody working in this type of business is part of a project and should be aware of the typical processes.
The lecturer provides a comprehensive overview about modern project management for small series of capital-intensive goods.
The content is not only valid for rail vehicles but also other areas.
The following topics will be discussed:
Introduction: definition of project and project management
Project management system: project phases, main processes and supporting processes, governance
Organization: organizational structure within a company, project organization, roles in a project organization
Main processes: project start, project plan, work brake down structure, detailed project schedule, risk and opportunity management, change management, project closure
Governance

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

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

Remarks
The lecture will be held for the last time in the winter term 2019.
Exams can be taken until the end of the examination period of the winter term 2020.

Course: Project management in Global Product Engineering Structures [2145182]

Coordinators: P. Gutzmer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
Auxilary means: none

Conditions
none

Learning Outcomes
Project management is essential for successful companies.
The students are able to describe, explain and compare characteristics and attributes of product development processes based on practical examples of industry.
They are able to specify processes of product development, their necessary organization structures and important attributes.
The participants learn to identify and evaluate aspects of product management within international operating companies.

Content
Product development process
Coordination of product development and handling of complexity
project management
matrix organization
planning / specification / target system
interaction of development and production

Literature
lecture notes

Course: ProVIL - Product development in a Virtual Idea Laboratory [2146210]

Coordinators: A. Albers, -
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
Certificate

Conditions
only for master studies

Recommendations
Parallel attending the course Produktentstehung - Entwicklungsmethodik

Learning Outcomes
The student is able to ...

- model problems of product development including their aspects (market, technology, product).
- systematically plan, conduct and interpret validation of product models.
- chosse development methods according to the situation and adapt it to realistic task assignments.

Content
The course ProVIL is conducted as innovation project with 4 phases and a real task assignment provided by a company. The students develop their own product concepts in teams while using modern hardware and software tools. In respect to this they conduct the following activities:

- Analysis of markets and products
- Identifikation and analysis of customer requirements
- Modelling of customer and company benefit as product profiles
- Validation of product profiles for markets
- Generation of solution ideas for technical implementation of product profiles
- Evaluation and selection of the best product ideas
- Implementation of selected ideas into funcional prototypes
- Evaluation of functional prototypes through planing, conduction and interpretation of suitable validation tasks.
- Presentation of prototypes at the project close-out with attendence of the project partner.

Literature
-

Remarks
The amount of participants is limited. Please apply for attendence on the IPEK homepage.

Course: Process Simulation in Forming Operations [2161501]

Coordinators: D. Helm
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination (30 min)

Conditions
None.

Learning Outcomes
The students can

- describe and classify the most important forming methods
- explain the reasons for the die Ursachen für die gute Umformbarkeit von Metallen in Bezug zu den stattfindenden Phänomenen in der Mikrostruktur erläutern und den Bezug zu den Abläufen in den unterschiedlichen Fertigungsverfahren herstellen
- describe the kinematics of infinitesimal and finite deformations
- explain the differences between different stress tensors in case of finite deformations
- apply simple material models of elasticity and plasticity and explain their operation
- derive the equation of the finite element method based on the balance laws
- describe why the material models are necessary and how they are applied in the whole algorithm
- sketch the process of a FEM-simulation and give the relation to the theoretical basis

Content
Based on basics of continuum mechanics, material theory and numerics the lecture gives an introduction into the simulation of forming operations for metals

- plasticity for metallic materials: dislocations, twinning, phase transformations, aniostropy, hardening
- classification of forming operations and discussion of selected topics
- basics of tensor algebra and tensor analysis
- continuum mechanics: kinematics, finite deformations, balance laws, thermdydnamics
- material theory: basics, modelling concepts, plasticity and visco plasticity, yield functions (von Mises, Hill, ...), kinematic and isotropic hardening, damage
- thermomechanical coupling
- modelling of contact
- finite element method: explicit and implicite formulations, types of elements, numerical integration of material models
- process simulation of selected problems of sheet metal forming

Course: Advanced powder metals [2126749]

Coordinators: R. Oberacker
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam (20-30 min) taking place at the agreed date. The re-examination is offered upon agreement.

Conditions
None.

Recommendations
Knowledge of basic material science is assumed.

Learning Outcomes
The students know the basics of powder metallurgy. They are able to assess the conditions for applying either powder metallurgy or competing production methods. They have knowledge on production, properties and application of the most important PM materials.

Content
The lecture gives an overview on production, properties and application of structural and functional powder metallurgy material. The following groups of materials are presented: PM High Speed Steels, Cemented Carbides, PM Metal Matrix Composites, PM Specialities, PM Soft Magnetic and Hard Magnetic Materials.

Media
Slides for the lecture:
available under http://ilias.studium.kit.edu

Literature

- W. Schatt ; K.-P. Wieters ; B. Kieback. „Pulvermetallurgie: Technologien und Werkstoffe“, Springer, 2007
- R.M. German. “Powder metallurgy and particulate materials processing. Metal Powder Industries Federation, 2005
- F. Thümmler, R. Oberacker. “Introduction to Powder Metallurgy”, Institute of Materials, 1993

Course: Quality Management [2149667]

Coordinators: G. Lanza
Part of the modules: Compulsory Elective Module Economics/Law (p. 45)[MSc-Modul 12, WF WR], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Supplementary Subject, Elective Subject Economics/Law: The assessment is carried out as a written exam.
Elective Subject/Compulsory Elective Module Mechanical Engineering: The assessment is carried out as a written exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students . . .

- are capable to comment on the content covered by the lecture.
- are capable of substantially quality philosophies.
- are able to apply the QM tools and methods they have learned about in the lecture to new problems from the context of the lecture.
- are able to analyze and evaluate the suitability of the methods, procedures and techniques they have learned about in the lecture for a specic problem.

Content
Based on the quality philosophies Total Quality Management (TQM) and Six Sigma, the lecture deals with the requirements of modern quality management. Within this context, the process concept of a modern enterprise and the process-specic elds of application of quality assurance methods are presented. The lecture covers the current state of the art in preventive and non-preventive quality management methods in addition to manufacturing metrology, statistical methods and service-related quality management. The content is completed with the presentation of certication possibilities and legal quality aspects.
Main topics of the lecture:

- The term “quality”
- Total Quality Management (TQM) and Six Sigma
- Universal methods and tools
- QM during early product stages – product denition
- QM during product development and in procurement
- QM in production – manufacturing metrology
- QM in production – statistical methods
- QM in service
- Quality management systems
- Legal aspects of QM

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Reactor Safety I: Fundamentals [2189465]

Coordinators: V. Sánchez-Espinoza
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination
Duration: approximately 30 minutes

Conditions
Knowledge in energy technology, nuclear power plants, reactor physics, thermal hydraulic of nuclear reactors is welcomed

Learning Outcomes

- Knowledge of fundamentals of nuclear safety (technology, safety concepts, nuclear regulation)
- Gain understanding of safety features and systems of a nuclear power plant
- Ability to understand the interactions of different areas e.g. thermal hydraulics, neutronics, materials, human factors, organisation and management of a nuclear power plant
- Get familiar with safety analysis methodologies for nuclear power plants
- Get insights about accidents and its radiological consequences e.g. Fukushima severe accident

Content
In the lecture, the fundamental principles and concepts of reactor safety explained. They facilitate the assessment of the safety status of nuclear power plants and the interpretation of incidents or accidents as such as Chernobyl or Fukushima. Starting with the explanations of the technical safety features of reactor systems, the safety concepts of different reactor types are discussed. The initiation and progression of incidents/accidents as well as the methods for the safety evaluation are also presented in this lecture. Discussing the Fukushima accident, the radiological risk from nuclear power plants together with the counter measures to stop severe accident and to limit the consequences will be explained. Finally, new development to increase the safety or reactors of Generation III and IV will be presented.
Lecture Content:

- National and international nuclear regulations
- Fundamental principles of reactor safety
- Implementation of safety principles in nuclear power plants of generation 2
- Safety analysis and methods for safety assessment
- Nuclear events and accidents and its evaluation methods
- Discussion severe accidents e.g. the Fukushima accident
- Safety features of reactor systems of generation 3 and 4

Literature

- G. Kessler at al; Risks of Nuclear Energy Technology- Safety Concepts of Light Water Reactors. Springer Verlag 2014.
- B. R. Sehgal; Nuclear Safety in LWR: Severe Accident Phenomenology. Academic Press Elsevier. 2012.
- John C. Lee and Norman J. McCormick.July; Risk and Safety Analysis of Nuclear Systems. 2011
- G. Petrangeli; Nuclear Safety. Elsevier Butterworth-Heinemann. 2006
- J. N. Lillington; Light Water Reactor Safety: The Development of Advanced Models and Codes for Light Water Reactor Safety Analysis. Elsevier 1995.

Course: Computational Vehicle Dynamics [2162256]

Coordinators: C. Proppe
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination, no auxiliary means allowed

Conditions
none

Recommendations
none

Learning Outcomes
This course serves as an introduction to the computational modelling and simulation of the technical system road/vehicle. A method based perspective is taken, which allows for a unified treatment of various kinds of vehicles. The vehicle model is obtained by dividing the system into functional subsystems and defining interfaces between these subsystems. In the first part of the course, vehicle models will be developed based on models of the suspensions, the road, and the contact forces between road and vehicle. The focus of the second part of the course is on computational methods for linear and non-linear models of vehicle systems. The third part of the course discusses design criteria for stability, safety and ride comfort.The multi body dynamics software Simpack will be used.

Content
1. Introduction
2. Models of load bearing systems
3. Contact forces between wheels and roadway
4. Simulation of roadways
5. Vehicle models
6. Methods of calculation
7. Performance indicators

Literature
1. K. Popp, W. Schiehlen: Fahrzeugdynamik, B. G. Teubner, Stuttgart, 1993
2. H.-P. Willumeit: Modelle und Modellierungsverfahren in der Fahrzeugdynamik, B. G. Teubner, Stuttgart, 1998
3. H. B. Pacejka: Tyre and Vehicle Dynamics. Butterworth Heinemann, Oxford, 2002
4. K. Knothe, S. Stichel: Schienenfahrzeugdynamik, Springer, Berlin, 2003

Remarks
The course takes place every two years (impair years only).

Course: Computerized Multibody Dynamics [2162216]

Coordinators: W. Seemann
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam

Conditions
None.

Recommendations
Knowledge of EM III, EM IV

Learning Outcomes
Goal of the course is to demonstrate the students that many tasks which are necessary to derive the equations of motion can be done by computers and corresponding software. This enables the user to focus both on mechanics and on modelling. This includes both kinematics as well as dynamcis and different methods to derive the equations of motion. The numerical integration is known and the students realize that the result of the simulation does not only depend on the physical model but also on the type of integration scheme and the corresponding parameters. Application of software without detailed knowledge of the principles which are behind this software is therefore dangerous.

Content
Description of the orientation of a rigid body, angular velocity, angular acceleration, derivatives in different referrence frames, derivatives of vectors, holonomic and nonholonomic constraints, derivation of the equations of motion using d'Alembert's principle, the principle of virtual power, Lagrange's equations or Kane's equations. Structure of the equations of motion, foundations of numerical integration.

Media
Following Programs are used: AUTOLEV, MATLAB, MATHEMATICA/MAPLE

Literature
Kane, T.: Dynamics, Theory and Applications, McGrawHill, 1985
AUTOLEV: User Manual

Course: Computational Mechanics I [2161250]

Coordinators: T. Böhlke, T. Langhoff
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination
Prerequisites by attestations during associated tutorials

Conditions
None.

Recommendations
Lectures "Mathematical Methods in Strength of Materials" and "Introduction to the Finite Element Method"
This course is geared to MSc students.

Learning Outcomes
The students can

- analyse and evaluate different methods for solving linear systems of equations
- list and assess basics and assumptions of the linear elasticity
- list methods for solving the boundary value problem of linear elasticity
- apply and evaluate the matrix displacement method
- list and analyse variational principles of linear elasticity
- analyse the different aspects and steps of the finite-element-method
- solve worksheet problems to topics of the lecture by writing own MATLAB code

Content

- numerical solution of linear systems
- basics of boundary value problems of linear elasticity
- solution methods of boundary value problem of linear elasticity;
- matrix displacement method
- variational principles of linear elasticity
- finite-element-technology for linear static problems

Literature
Simó, J.C.; Hughes, T.J.R.: Computational Inelasticity. Springer 1998.
Haupt, P.: Continuum Mechanics and Theory of Materials. Springer 2002.
Belytschko, T.; Liu,W.K.; Moran, B.: Nonlinear FE for Continua and Structures. JWS 2000.
W. S. Slaughter: The linearized theory of elasticity. Birkhäuser, 2002.
J. Betten: Finite Elemente für Ingenieure 2, Springer, 2004.

Course: Computational Mechanics II [2162296]

Coordinators: T. Böhlke, T. Langhoff
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	de

Learning Control / Examinations
oral examination

Conditions
Successful participation in lecture "Computational Mechanics I"

Recommendations
This course is geared to MSc students.

Learning Outcomes
The students can

- apply and evaluate algorithms for solving a non-linear equation of systems of equations
- compute stresses and strains in the framework of linear elasticity and of infinitesimal plasticity
- apply and assess models of generalized standard materials
- list the basic equations of linear thermo-elasticity
- develop user-subroutines within FORTRAN for use within commercial FE-Codes
- perform a finite-element-analysis with ABAQUS for elastic-plastic materials using or developing user-subroutines

Content

- overview quasistatic nonlinear phenomena
- numerics of nonlinear systems
- foundations of nonlinear continuum mechanics
- balance equations of geometrically nonlinear solid mechanics
- finite elasticity
- infinitesimal plasicity
- linear and gemetrically nonlinear thermoelasticity

Literature
Simó, J.C.; Hughes, T.J.R.: Computational Inelasticity. Springer 1998.Haupt, P.: Continuum Mechanics and Theory of Materials. Springer 2002.Belytschko, T.; Liu,W.K.; Moran, B.: Nonlinear FE for Continua and Structures. JWS 2000.

Course: Reduction methods for the modeling and the simulation of combustion processes [2166543]

Coordinators: V. Bykov, U. Maas
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
None

Learning Outcomes
After completing this course students will be able to:

- explain the fundamental mathematical concepts in model reduction for reacting flows,
- perform an analysis of kinetic models of reacting flows,
- analyse ideal and reduced models used to describe different combustion regimes,
- understand and asses the predominant methods for the mathematical analysis of reduced models.

Content
The course will introduce the principles of model reduction of chemical kinetic models of combustion processes. The basic mathematical concepts and methods of analysis of chemical reaction mechanisms will be outlined in the context of model reduction. The detailed implementation scheme of model reduction will be introduced. The course will cover simplified and idealized models of combustion (e.g. auto-ignition, explosion, deflagration etc.), which will be analyzed and reduced. The main analytical methods and numerical tools will be presented, evaluated and illustrated by using these simple examples.

Literature
N. Peters, B. Rogg: Reduced kinetic mechanisms for aplication in combustion systems, Lecture notes in physics, 15, Springer Verlag, 1993.

Course: Failure Analysis [2182572]

Coordinators: C. Greiner, J. Schneider
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral

Duration: ca. 30 minutes

no notes

Conditions
None.

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

Learning Outcomes
The students are able to discuss damage evaluation and to perform damage investigations. They know the common necessary investigation
methods and can regard failures considering load and material resistance. Furthermore they can describe and discuss the most important types of failure and damage appearance.

Content
Aim, procedure and content of examining failure

Examination methods

Types of failure:
Failure due to mechanical loads
Failure due to corrosion in electrolytes
Failure due to thermal loads
Failure due to tribological loads

Damage systematics

Literature

1. G. Lange: Systematische Beurteilung technischer Schadensfälle, 6. Auflage, WILEY-VCH Verlag, 2014, ISBN 978-3-527-68316-1, In der KIT-BIB online verfügbar!
2. A. Neidel, et al.: Handbuch Metallschäden – REM-Atlas und Fallbeispiele zur Ursachenanalyse und Vermeidung, 2. Auflage, Hanser Verlag, 2011, ISBN 978-3-446-42966-6
3. J. Grosch, et al.: Schadenskunde im Maschinenbau: Charakteristische Schadensursachen – Analyse und Aussagen von Schadensfällen, 6. Auflage, Expert-Verlag, 2014, ISBN 978-3-816-93172-0
4. E. Wendler-Kalsch, H. Gräfen: Korrosionsschadenkunde, Springer-Verlag, 1998, ISBN 3-540-63377-4

Course: Rail Vehicle Technology [2115996]

Coordinators: P. Gratzfeld
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes
The students are familiar with concept and structure of modern rail vehicles.
They learn about advantages and disadvantages of different types of traction drives and judge which one fits best for each application.
They understand brakes from a vehicular and an operational point of view. They assess the fitness of different brake systems.
They know about the basics of running dynamics and bogies.
They define suitable vehicle concepts based on requirements for modern rail vehicles.

Content
System structure of rail vehicles: tasks and classification of rail vehicles, main systems, vehicle system technology
Drives: Electric and non-electric traction drives
Brakes: Tasks, basics, principles, brake control
Bogies: forces, running gears, axle configuration
Vehicle concepts: trams, metros, regional trains, double deck coaches, locomotives
Examples of existing rail vehicles were discussed.

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

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

Remarks
None.

Course: Fatigue of Metallic Materials [2173585]

Coordinators: K. Lang
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam, about 20 minutes

Conditions
none

Recommendations
Basic knowledge in Material Science will be helpful

Learning Outcomes
The students are able to recognise the deformation and the failure behaviour of metallic materials under cyclic loading and to assign it to the basic microstructural processes. They know the sequence and the development of fatigue damages and can evaluate the initiation and the growth of fatigue cracks.
The students can assess the cyclic strength behaviour of metallic materials and components both qualitatively and quantitatively and know the procedures for the assessment of single-stage, multistage and stochastic cyclical loadings. Furthermore, they can take into account the influence of residual stresses.

Content
Introduction: some interesting cases of damage
Cyclic Stress Strain Behaviour
Crack Initiation
Crack Propagation
Lifetime Behaviour under Cyclic Loading
Fatigue of Notched Components
Influence of Residual Stresses
Structural Durability

Literature
Lecture notes that include a list of current literature will be distributed.

Course: Schwingungstechnisches Praktikum [2161241]

Coordinators: A. Fidlin
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
Colloquium to each session.

Conditions
The courses [2161241] and [2162225] can not be combined.

Recommendations
Vibration theory, mathematical methods of vibration theory, dynamic stability, nonlinear vibrations

Learning Outcomes
* Introduction to common measurement principles for mechanical vibrations
* selected vibrational problems are demonstrated from a theoretical and experimental aspect
* Measurement, evaluation and
comparison with analytical calculations.

Content
* Frequency response of a force-excited oscillator (1DoF)
* stochastically excited oscillator (1DoF)
* digital processing of measurement data
* forces vibrations of a Duffing oscillator
* isolation of acoustical waves by means of additional masses
* critical speeds of a rotor in elastic bearings
* stability of a parametrically excited oscillator
* experimental modal analysis
* friction induced vibrations

Literature
comprehensive instructions will be handed out

Course: Seminar for Rail System Technology [2115009]

Coordinators: P. Gratzfeld
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter / Summer Term	de

Learning Control / Examinations
Examination: Writing a Seminararbeit, final presentation

Conditions
None.

Learning Outcomes

- The students become aware of the fundamental relations and interdependencies between rail vehicles, infrastructure and operation in a rail system.
- They are able to explain the railway history along general lines, to analyse the status quo and future developments of the railway and mobility sector.
- They overview the technical components of a rail system (in particular rail vehicle engineering).
- The students be aware of the characteristics of a project and the meaning of project management. They are able to transfer their project knowledge to the task of creating a scientific paper.
- They are able to specify the essential requirements on scientific papers, to do a literature research and to use software to manage literature.

Content

- Railway system: railway as system, subsystems and interdependencies, definitions, laws, rules, railway and environment, economic impact, history, challenges and future developments in the context of mega trends
- Operation: Transportation, public/regional/long-distance transport, freight service, scheduling
- System structure of railway vehicles: Tasks and classification, main systems
- Project management: definitions, project management, main and side processes, transfer to practice
- Scientific working: structuring and writing of scientific papers, literature research, scheduling (mile stones), self-management, presentation skills, using the software Citavi for literature and knowledge management, working with templates in Word, giving and taking feedback
- The learnt knowledge regarding scientific writing is used to elaborate a Seminararbeit. To this the students create a presentation, train and reflect it and finally present it to an auditorium.

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

Remarks
max. 10 participants

Course: Safety Engineering [2117061]

Coordinators: H. Kany
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral / written (if necessary)

Conditions
none

Recommendations
none

Learning Outcomes
Students are able to:

- Name and describe relevant safety conceps of safety engeneering,
- Discuss basics of health at work and labour protection in Germany,
- Evaluate the basics for the safe methods of design of machinery with the national and european safety regulations and
- Realize these objectives by using examples in the field of storage and material handling systems.

Content
The course provides basic knowledge of safety engineering. In particular the basics of health at the working place, job safety in Germany, national and European safety rules and the basics of safe machine design are covered. The implementation of these aspects will be illustrated by examples of material handling and storage technology. This course focuses on: basics of safety at work, safety regulations, basic safety principles of machine design, protection devices, system security with risk analysis, electronics in safety engineering, safety engineering for storage and material handling technique, electrical dangers and ergonomics. So, mainly, the technical measures of risk reduction in specific technical circumstances are covered.

Media
presentations

Literature
Defren/Wickert: Sicherheit für den Maschinen- und Anlagenbau, Druckerei und
Verlag: H. von Ameln, Ratingen, ISBN: 3-926069-06-6

Remarks
none

Course: Signals and Systems [23109]

Coordinators: F. Puente, F. Puente León
Part of the modules: Compulsory Elective Module Natural Science/Computer Science/Electrical Engineering (p. 44)[MSc-Modul 11, WF NIE]

ECTS Credits	Hours per week	Term	Instruction language
6	2/1	Winter term	de

Learning Control / Examinations
The assessment consists of a written exam (approx. 120 minutes) according to sec. 4 subsec. 2 no. 1 study and examination regulations.
The grade of the course corresponds to the grade of the written exam.

Conditions
Knowledge of higher mathematics and probability theory (1305) is required.

Learning Outcomes

Content

Media
Slides
work sheets

Literature
Prof. Dr.-Ing. Kiencke: Signale und Systeme; Oldenbourg Verlag, 2008
Elective literature:
Will be announced in the lecture.

Course: Simulation of Coupled Systems [2114095]

Coordinators: M. Geimer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.
Required for the participation in the examination is the preparation of a report during the semester.

Conditions
None.

Recommendations
It is recommended to have:

- Knowledge of Creo (ideally in current version)
- Basic knowledge of Matlab/Simulink
- Basic knowledge of dynamics of machines
- Basic knowledge of hydraulics

Learning Outcomes
After completion of the course, students are able to:

- build a coupled simulation
- parameterize models
- perform simulations
- conduct troubleshooting
- check results for plausibility

Content

- Basics of multi-body and hydraulic simulation programs
- Possibilities of coupled simulations
- Modelling and Simulation of Mobile Machines using a wheel loader
- Documentation of the result in a short report

Literature
Elective literature:

- Software guide books (PDFs)
- Information about wheel-type loader specifications

Remarks
The number of participants is limited. A registration is mandatory, the details will be announced on the webpages of the *Institute of Vehicle System Technology / Institute of Mobile Machines*. In case of too many applications, attendance will be granted based on pre-qualification.

Course: Simulator Exercises Combined Cycle Power Plants [2170491]

Coordinators: T. Schulenberg
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
Oral examination (ca. 15 min)

Conditions
None.

Recommendations
Participation at the lecture Combined Cycle Power Plants (2170490) is recommended.

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in power plant engineering. On the basis of the learned fundamentals in thermodynamics, in instrumentation and control engineering, as well as on the basis of the acquired knowledge of design of combined cycle plants, the participants can operate a real combined cycle power plant. This application creates a deeper understanding of the dynamic processes of the power plant, the specific importance of the plant components and the limits of the load capacity of the components. Participants can optimize normal operation and analyze incidents. They can work self-organized and reflexive. They have communicative and organizational skills in teamwork, even under major technical challenges.

Content
Start-up of the power plant from scratch; load changes and shut down; dynamic response of the power plant in case of malfuctions and of sudden load changes; manual operation of selected components.

Media
The power plant simulator is based on the control system of a real SIEMENS power plant. The English user surface is based on US standard.

Literature
Slides and other documents of the lecture Combined Cycle Power Plants.

Course: Scaling in fluid dynamics [2154044]

Coordinators: L. Bühler
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral
Duration: 30 minutes
no auxiliary means

Conditions
none

Learning Outcomes
The student can extract non-dimensional number from the characteristic properties of flows. From the insights on scaling laws, the students are qualified to identify the influencing quantities from generic experiments and transfer these to real applications. The students can simplify the governing equations of fluid mechanic appropriately and can interpret the achieved results as a basis for efficient solution strategies.

Content

- Introduction
- Similarity rules (examples)
- Dimensional analysis (Pi-theorem)
- Scaling in differential equations
- Scaling in boundary layers
- Self-similar solutions
- Scaling in turbulent shear layers
- Rotating flows
- Magnetohydrodynamic flows

Literature
G. I. Barenblatt, 1979, Similarity, Self-Similarity, and Intermediate Asymptotics, Plenum Publishing Corporation (Consultants Bureau)
J. Zierep, 1982, Ähnlichkeitsgesetze und Modellregeln der Strömungsmechanik, Braun
G. I. Barenblatt, 1994, Scaling Phenomena in Fluid Mechanics, Cambridge University Press

Course: Solar Thermal Energy Systems [2189400]

Coordinators: R. Dagan
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The students
get familiar with the global energy demand and the role of renewable energies
learn about improved designs for using efficiently the potential of solar energy
gain basic understanding of the main thermal hydraulic phenomena which support the work on future innovative applications
will be able to evaluate quantitatively various aspects of the thermal solar systems

Content
I. Introduction to solar energy: Energy resources, consumption and costs
II. The sun as an energy resource:
Structure of the sun, Black body radiation, solar constant, solar spectral distribution
Sun-Earth geometrical relationship
III. Passive and active solar thermal applications.
IV. Fundamentals of thermodynamics and heat transfer
V. Solar thermal systems - solar collector-types, concentrating collectors, solar towers. Heat losses and efficiency
VII. Energy storage
The course deals with fundamental aspects of solar energy. Starting from a global energy panorama the course deals with the sun as a thermal energy source. In this context, basic issues such as the sun's structure, blackbody radiation and solar–earth geometrical relationship are discussed. In the next part, the lectures cover passive and active thermal applications and review various solar collector types including concentrating collectors and solar towers and the concept of solar tracking. Further, the collector design parameters determination is elaborated, leading to improved efficiency. This topic is augmented by a review of the main laws of thermodynamics and relevant heat transfer mechanisms.
The course ends with an overview on energy storage concepts which enhance practically the benefits of solar thermal energy systems.

Literature
Foster, Ghassemi, cota,; Solar Energy
Duffie and Beckman; Solar engineering of thermal processes
Holman:, Heat transfer
Heinzel; script to solar thermal energy (in German)

Course: Theory of Stability [2163113]

Coordinators: A. Fidlin
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	de

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Vibration theory, mathematical methods of vibration theory

Learning Outcomes

- to learn the most important methods of the stability analysis
- to apply the stabiliy analysis for equilibria
- to apply the stabiliy analysis for periodic solution
- to apply the stabiliy analysis for systems with feedback control

Content

- Basic concepts of stability
- Lyapunov's functions
- Direct lyapunov's methods
- Stability of equilibria positions
- Attraction area of a stable solution
- Stability according to the first order approximation
- Systems with parametric excitation
- Stability criteria in the control theory

Literature

- Pannovko Y.G., Gubanova I.I. Stability and Oscillations of Elastic Systems, Paradoxes, Fallacies and New Concepts. Consultants Bureau, 1965.
- Hagedorn P. Nichtlineare Schwingungen. Akademische Verlagsgesellschaft, 1978.
- Thomsen J.J. Vibration and Stability, Order and Chaos. McGraw-Hill, 1997.

Course: Control Technology [2150683]

Coordinators: C. Gönnheimer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment is carried out as an oral exam. In case of a great number of participating students assessment is carried out as a written exam. Oral exams then are only carried out in the event of repetition.

Conditions
None

Recommendations
This course is geared to MSc students.

Learning Outcomes
The students . . .

- are able to name the electrical controls which occur in the industrial environment and explain their function.
- can explain fundamental methods of signal processing. This involves in particular several coding methods, error protection methods and analog to digital conversion.
- are able to choose and to dimension control components, including sensors and actors, for an industrial application, particularly in the field of plant engineering and machine tools. Thereby, they can consider both, technical and economical issues.
- can describe the approach for projecting and writing software programs for a programmable logic control named Simatic S7 from Siemens. Thereby they can name several programming languages of the IEC 1131.

Content
The lecture control technology gives an integral overview of available control components within the field of industrial production systems. The first part of the lecture deals with the fundamentals of signal processing and with control peripherals in the form of sensors and actors which are used in production systems for the detection and manipulation of process states. The second part handles with the function of electric control systems in the production environment. The main focus in this chapter is laid on programmable logic controls, computerized numerical controls and robot controls. Finally the course ends with the topic of cross-linking and decentralization with the help of bus systems.
The lecture is very practice-oriented and illustrated with numerous examples from different branches.
The following topics will be covered

- Signal processing
- Control peripherals
- Programmable logic controls
- Numerical controls
- Controls for industrial robots
- Process control systems
- Field bus
- Trends in the area of control technology

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Strategic product development - identification of potentials of innovative products [2146198]

Coordinators: A. Siebe
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam
duration: 20 minutes

Conditions
none

Learning Outcomes
After listening to this lecture the students is able to ...

- describe the importance and goals of future management in product planning.
- to evaluate the different approaches of strategic product planning under consideration of the particular application.
- describe the approaches of a strategic szenario-based product planning.
- illustrate the strategic szenario-based product planning based on examples.

Content
Introduction into future management, Development of scenarios, scenariobased strategy development, trendmanagement, strategic early detection, innovation- and technologymanagement, scenarios in product development, from profiles of requirements to new products, examples out of industrial praxis.

Course: Flows with chemical reactions [2153406]

Coordinators: A. Class
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Compulsory Elective Module Natural Science/Computer Science/Electrical Engineering (p. 44)[MSc-Modul 11, WF NIE]

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

Learning Control / Examinations
Oral examination

Duration: 30 min
as WF NIE
written homework

Lecture

Conditions
None.

Recommendations
Mathematics

Learning Outcomes
The students can describe flow scenarios, where a chemical reaktion is confined to a thin layer. They can choose simplifying approaches for the underlying chemistry and discuss the problems with focus on the fluid mechanic aspects. The students are able to solve simple problems analytically. Furthermore, they are qualified to discuss simplifications as relevant for an efficent numerical solution of complex problems.

Content
In the lecture we mainly consider problems, where chemical reaktion is confined to a thin layer.
The problems are solved analytically or they are at least simplified allowing for efficent numerical
sollution procedures. We apply simplified chemistry and focus on the fluid mechanic aspects of the problems.

Media
Black board

Literature
Lecture

Buckmaster, J.D.; Ludford, G.S.S.: Lectures on Mathematical Combustion, SIAM 1983

Course: Flows and Heat Transfer in Energy Technology [2189910]

Coordinators: X. Cheng
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination; duration: 20min

Conditions
None.

Learning Outcomes
This lecture is dedicated to students of mechanical engineering and other engineering Bachelor or Master degree courses. Goal of the lecture is the understanding of major processes in fluid dynamics and heat transfer in energy engineering. Through this lecture the students are capable of understanding the important physical processes and the selection of suitable methods for the analysis of the processes. With the discussion of some practical examples, the students can analyze the pressure drop and heat transfer in energy engineering systems.

Content

1. collection of sample applications
2. heat transfer and its application
3. convective fluid dynamics and heat transfer
4. thermal radiation and its application
5. special cases

Literature

- Bahr, H.D., Stephan, K., Wärme- und Stoffübertragung, 3. Auflage Springer Verlag, 1998
- Mueller, U., Zweiphasenströmung, Vorlesungsmanuskript, Februar 2000, TH Karlsruhe
- Mueller, U., Freie Konvektion und Wärmeübertragung, Vorlesungsmanuskript, WS1993/1994, TH Karlsruhe
- W. Oldekop„Einführung in die Kernreaktor und Kernkraftwerktechnik,“Verlag Karl Thiemig, München, 1975
- Cacuci, D.G., Badea, A.F., Energiesysteme I, Vorlesungsmanuskript, 2006, TH Karlsruhe
- Jones, O.C., Nuclear Reactor Safety Heat Transfer, Hemisphere Verlag, 1981
- Herwig, H., Moschallski, A., Wärmeübertragung, 2. Auflage, Vieweg + Teubner, 2009

Course: Flow Measurement Techniques [2155425]

Coordinators: J. Kriegseis
Part of the modules: Specialized Practical Training (p. 33)[MSc-Modul 07, FP]

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

Learning Control / Examinations
Participation in at least 7 out of 9 events, successful initial colloquium prior to the respective measurements and submission of a significant report after every experiment

Conditions
none

Recommendations
The content of lecture “Experimental Fluid Mechanics” (LVNr. 2154446)

Learning Outcomes
The students can apply various flow measurements. They are capable to obtain, (post-)process and analyze flow data. Furthermore, the students can contrast advantages and disadvantages of the respective experimental approaches.

Content
The following flow measurement techniques are considered:
- wind tunnel techniques and estimation of turbulence intensity
- hot wire calibration an measzrement
- pressure measurements in air (around bodies)
- pressure measurements in water (Nikuradse diagram)
- Schlieren techniques
- Mach-Zehnder interferometry
- laser Doppler anemometry
- particle image velocimetry
- uncertainty estimation

Media
chalkboard or whiteboard, Power Point, experiments

Literature
Tropea, C., Yarin, A.L., Foss, J.F.: Springer Handbook of Experimental Fluid Mechanics, Springer 2007
Nitsche, W., Brunn, A.: Strömungsmesstechnik, Springer, 2006
Spurk, J.H., Aksel, N: Fluid Mechanics, Springer, 2008

Remarks
Limited number of participants, registration in the secretary’s office at ISTM is required, selection procedure in case of over-booking, details can be found at the web page.

Course: Structural and phase analysis [2125763]

Coordinators: S. Wagner, M. Hinterstein
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
20 min
auxiliary means: none

Conditions
None.

Learning Outcomes
The students know the fundamentals of crystallography, the generation and detection of x-rays as well as their interaction with the microstructure of crystalline materials. They have detailed knowledge about the different methods of x-ray diffraction measurements and are able to analyse x-ray spectra using modern methods of x-ray analysis both qualitatively and quantitatively.

Content
The course gives an overview to generation and detection of x-rays as well as their interaction with matter. It provides an introduction to crystallography and describes modern measurement and analysis methods of x-ray diffraction.
It is arranged in the following units:

- Generation and properties of X-Ray's
- Crystallography
- Fundamentals and application of different measuring methods
- Qualitative and quantitative phase analysis
- Texture analysis (pole figures)
- Residual stress measurements

Media
Slides for the lecture:
available unter http://ilias.studium.kit.edu

Literature

1. Moderne Röntgenbeugung - Röntgendiffraktometrie für Materialwissenschaftler, Physiker und Chemiker, Spieß, Lothar / Schwarzer, Robert / Behnken, Herfried / Teichert, Gerd B.G. Teubner Verlag 2005
2. H. Krischner: Einführung in die Röntgenfeinstrukturanalyse. Vieweg 1990.
3. B.D. Cullity and S.R. Stock: Elements of X-ray diffraction. Prentice Hall New Jersey, 2001.

Course: Structural Ceramics [2126775]

Coordinators: M. Hoffmann
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam (20 min) taking place at a specific date.
Auxiliary means: none
The re-examination is offered at a specific date.

Conditions
none

Recommendations
Basics of the course "Introduction to Ceramics" should be known.

Learning Outcomes
The students know the most relevant structural ceramics (silicon carbide, silicon nitride, alumina, boron nitride, zirconia, fibre-reinforced ceramics) and their applications. They are familar with the microstructural features, fabrication methods, and mechanical properties.

Content
The lecture gives an overview on structure and properties of the technical relevant structural ceramics silicon nitride, silicon carbide, alumina, zirconia, boron nitride and fibre-reinforced ceramics. All types of structural ceramics will be discussed in detail in terms of preparation methods of the raw materials, shaping techniques, densification, microstructural development, mechanical properties and application fields.

Media
Slides for the lecture:
available under http://ilias.studium.kit.edu

Literature
W.D. Kingery, H.K. Bowen, D.R. Uhlmann, "Introduction to Ceramics", John Wiley & Sons, New York, (1976)

E. Dörre, H. Hübner, "Aluminia", Springer Verlag Berlin, (1984)

M. Barsoum, "Fundamentals of Ceramics", McGraw-Hill Series in Material Science and Enginewering (2003)

Remarks
The course will not take place every year.

Course: Superconducting Materials for Energy Applications [23682]

Coordinators: F. Grilli
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	en

Learning Control / Examinations
The examination results from the chosen module, otherwise:
Oral exam, about 25 min.

Conditions
None.

Learning Outcomes
After attending this course, the students will have

- Received an introduction to superconductivity, with an overview of its main features and of the theories developed to explain it;
- Learned about superconducting materials and their properties, especially those currently employed in energy applications (niobium-based superconductors, cuprates, MgB2) and promising recently discovered ones (pnictides);
- Familiarized with the wide range of superconducting energy applications (magnets, cables, fault current limiters, motors, transformers, etc.), and learned about the advantages they offer with respect to their conventional counterparts.

Content

- Introduction of the course
- Basics of superconductivity
- Materials I (low-T_c superconductors)
- Materials II (high-T_c superconductors)
- Stability
- AC losses
- Simulation and modeling
- Cables
- Fault current limiters
- Magnets, motors, transformers
- Smart-grids
- Lab tour

Media
Blackboard, PowerPoint slides, script written by the teacher (100+ pages)

Literature
Various. It will be provided on a lecture-by-lecture basis.

Remarks
Current information can be found on the IMS (www.ims.kit.edu) webpage. At the end of the course an excursion is planned to KIT Campus North (ITEP).

Course: Superhard Thin Film Materials [2177618]

Coordinators: S. Ulrich
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination (30 min)

no tools or reference materials

Conditions
None

Recommendations
None

Learning Outcomes
Superhard materials are solids with a hardness higher than 4000 HV 0,05. The main topics of this lecture are modelling, deposition, characterization and application of superhard thin film materials.

Content
Introduction

Basics

Plasma diagnostics

Particle flux analysis

Sputtering and ion implantation

Computer simulations

Properties of materials, thin film deposition technology,
thin film analysis and modelling of superhard materials

Amorphous hydrogenated carbon

Diamond like carbon

Diamond

Cubic Boronnitride

Materials of the system metall-boron-carbon-nitrogen-silicon

Literature
G. Kienel (Ed.): Vakuumbeschichtung 1 - 5, VDI Verlag, Düsseldorf, 1994

Copies with figures and tables will be distributed

Course: Supply chain management [2117062]

Coordinators: K. Alicke
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination

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

Conditions
None.

Recommendations
none

Learning Outcomes
Students are able to:

- Discuss the requirements on modern supply chains,
- Use the basic concepts of demand forecast, stock optimization and supply in practical exercises,
- Analyse the typical questions of dimensioning a supply chain and evaluate a supply chain with the results.

Content

- Bullwhip-Effect, Demand Planning & Forecasting
- Conventional planning processes (MRP + MRPII)
- Stock keeping strategy
- Data acquisition and analysis
- Design for logistics (Postponement, Mass Customization, etc.)
- Logistic partnerships (VMI, etc.)
- Distribution structures (central vs. distributed, Hub&Spoke)
- SCM-metrics (performance measurement) e-business
- Special sectors as well as guest lectures

Media
presentations

Literature
Alicke, K.: Planung und Betrieb von Logistiknetzwerken

Simchi-Levi, D., Kaminsky, P.: Designing and Managing the Supply Chain

Goldratt, E., Cox, J.: The Goal

Remarks
this course is not offered at the moment
this course is a block course
limited number: application necessary

Course: Sustainable Product Engineering [2146192]

Coordinators: K. Ziegahn
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The type of examination (written or oral) will be announced at the beginning of the lecture.
written examination: 60 min duration
oral examination: 20 min duration

Conditions
none

Learning Outcomes
The goal of the lecture is to convey the main elements of sustainable product development in the economic, social and ecological context.
The students are able to ...

- identify und describe the sustainability objectives and their role in product development, the interaction between technical products and their environment, the holistic approach and the equality of economic, social and environmental aspects and environmental aspects.
- discuss the skills for life-cycle product design using the example of complex automotive components such as airbag systems and other current products.
- understand the product environmental stresses with relevancy to praxis at the example of technology-intensive components, robustness and durability of products as the basis for a sustainable product development, development of skills for the application of environmental simulationduring the process of developement of technical products.
- develop skills such as team skills / project / self / presentation based on realistic projects.

Content
understanding of sustainability objectives and their role in product development, the interaction between technical products and their environment, the holistic approach and the equality of economic, social and environmental aspects and environmental aspects
skills for life-cycle product design using the example of complex automotive components such as airbag systems and other current products
understanding of product environmental stresses with relevancy to praxis at the example of technology-intensive components, robustness and durability of products as the basis for a sustainable product development, development of skills for the application of environmental simulationduring the process of developement of technical products
delivery of key skills such as team skills / project / self / presentation based on realistic projects

Course: Systematic Materials Selection [2174576]

Coordinators: S. Dietrich

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

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

Learning Control / Examinations
The assessment is carried out as a written exam of 2 h.

Conditions
Materials Science I/II or Materials Physics and Metals must be passed.

Recommendations
Basic knowledge in materials science, mechanics and mechanical design due to the lecture Materials Science I/II.

Learning Outcomes
The students are able to select the best material for a given application. They are proficient in selecting materials on base of performance indices and materials selection charts. They can identify conflicting objectives and find sound compromises. They are aware of the potential and the limits of hybrid material concepts (composites, bimaterials, foams) and can determine whether following such a concept yields a useful benefit.

Content
Important aspects and criteria of materials selection are examined and guidelines for a systematic approach to materials selection are deeloped. The following topics are covered:

- Information and introduction
- Necessary basics of materials
- Selected methods / approaches of the material selection
- Examples for material indices and materials property charts
- Trade-off and shape factors
- Sandwich materials and composite materials
- High temperature alloys
- Regard of process influences
- Material selection for production lines
- Incorrect material selection and the resulting consequences
- Abstract and possibility to ask questions

Literature
Lecture notes; Problem sheets; Textbook: M.F. Ashby, A. Wanner (Hrsg.), C. Fleck (Hrsg.);
Materials Selection in Mechanical Design: Das Original mit Übersetzungshilfen
Easy-Reading-Ausgabe, 3. Aufl., Spektrum Akademischer Verlag, 2006
ISBN: 3-8274-1762-7

Course: Systems and Software Engineering [23605]

Coordinators: E. Sax
Part of the modules: Compulsory Elective Module Natural Science/Computer Science/Electrical Engineering (p. 44)[MSc-Modul 11, WF NIE]

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

Learning Control / Examinations
Written exam.

Conditions
None.

Recommendations
Knowledge of the fundamentals of digital systems design and information technology.

Learning Outcomes
After attendacne of the course students are able to:

- solve complexe tasks in a structured and targeted way by applying methods, techniques and tools presented in the lecture.
- understand the concepts of System, systems engineering and software engineering.
- describe mathematical models of embedded systems and life cycle models.
- define specifications and develope project requirement documents and functional specifications applying description techniques and specification languages and formalisms.
- understand important topics of hardware design such as state charts, realization alternatives for electronic computation systems, aspects of concurrency and parallelization, pipelining, scheduling, real time systems and appropriate operating systems.
- describe mathematical models for reliability and operabality of complex electronic systems as well as risk assessment and simplified representations .
- describe the fundamentals of various languages and representations in software design.
- implement different testing and maintenance approaches.
- apply these fundamentals to specific and practical problems.

Content
The lecture Systems and Software Engineering is directed to all students, who themselves want to be challenged with the design of complex electronic systems with hardware and software components. It will introduce to students the tools, which allow for a structured solution to complex Problems. The lecture specially dwells on development processes, hardware design, software design, reliability as well as various aspects of modeling.
The lecture initially differentiates the terms system, systems engineering and software engineering. Life cycle models and methods for mathematical modeling of embedded electronic systems as well as lifecycle models (Waterfall model, V-Model and Hunger Model) are introduced. The focuses of the lecture are the early phases of system development, starting with definitions of requirements as well as the creation of project requirement documents and functional specifications. Aspects of requirements documentation methods and description techniques as well as specification languages and formalisms are brought near.
Concrete topics in the area of hardware design are state charts, realization alternatives for electronic computation systems, aspects of concurrency and parallelization, pipelining, scheduling, real time systems and the appropriate operating systems.
The domain reliability thematizes security and operability of complex electronical systems covering their complete lifetime. Mathematical modeling methods as well as risk analysis and simplified presentations like block diagrams are discussed.

Besides the various diagrams and modeling perspectives of UML (Use Case diagram, class diagram, object diagram, communication diagram, sequence diagram, package diagram, etc.) the area of software design covers dataflow diagram, Petri nets as well as various languages like the ENBF.
Testing and maintenance form another essential aspect of the system development. Approaches and procedures like black box testing and white box testing are presented and form a basic understanding for the importance of testing, verification and validation as well as quality assurance all over the development period.
Exercise
Exercises concerning the lecture as well as their appropriate solutions are handed out and discussed in the lecture hall exercise session. Transferring the lecture's theoretical content to examples with practical orientation clarify the usage and necessarity of techniques for modeling and representation techniques.

Literature
Course book online estudium.fsz.kit.edu.

Course: Technical Acoustics [2158107]

Coordinators: M. Gabi
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral examination
Duration: 30 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes
Students get to know the basics of technical acoustics in general. Application of the knowledge in different fields of engineering.
Students learn physical basics of acoustics and human perception. Physical-empirical laws for determination of sound and noise levels of various emission and immission situations will be worked out or derived. Furtheron general sound measurement methods of machinery will be taught.
Students are able to understand mechanisms of sound origin, propagation and reduction, as well as measuring technics

Content
Basics of acoustics
Perception and weighting of noise (human hearing)
Description of acoustic parameters, level notation
Noise propagation
Acoustical measurement techniques

Literature
1. Lecture notes (downloadable from institute's homepage).
2. Heckl, M.; Müller, H. A.: Taschenbuch der Technischen Akustik, Springer-Verlag.
3. Veit, Ivar: Technische Akustik. Vogel-Verlag (Kamprath-Reihe), Würzburg.
4. Henn, H. et al.: Ingenieurakustik. Vieweg-Verlag.

Course: Fundamentals of Combustion Engine Technology [2133123]

Coordinators: S. Bernhardt, H. Kubach, J. Pfeil, O. Toedter, U. Wagner, A. Velji

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

ECTS Credits	Hours per week	Term	Instruction language
5	2	Winter term	de

Learning Control / Examinations
as core subject in major field: oral exam approx. 25 minutes
as Compulsory Elective Subject: written exam approx. 1 h

Conditions
None.

Learning Outcomes
The student can name the engines compontents and systems. He can explain the interactions of the systems and their influence on the engine process.

Content
Fundamentals of engine processes
Components of combustion engines
Mixture formation systems
Gasexchange systems
Injection systems
Engine Control units
Cooling systems
Transmission

Media
Slides

Course: Computer Engineering [2106002]

Coordinators: M. Lorch, H. Keller
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Compulsory Elective Module Natural Science/Computer Science/Electrical Engineering (p. 44)[MSc-Modul 11, WF NIE]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	de

Learning Control / Examinations
Written examination

Duration: 2 hours (compulsory subject)

Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students possess essential knowledge about information processing in digital computers. Based on information representation and calculations of complexity, students are capable to design algorithms efficiently. The students are able to apply the knowledge about efficient algorithm design to important numerical computation methods in mechanical engineering. Students have basic knowledge of real-time systems and their development. Students can use the knowledge to develop real-time systems for reliable automation of technological systems in mechanical engineering.

Content
Introduction: definitions, basic concepts, introductory examples

Information coding on finite automata: numbers, characters, commands, examples

Algorithm design: definitions, complexity of algorithms, complexity classes P and NP, examples

Sorting algorithms: relevance, algorithms, simplifications, examples

Software quality assurance: terms and measures, errors, phases of quality assurance, constructive measures, analytical measures, certification

Lectures are complemented by an exercice course.

Literature
Lecture Notes (Ilias)

Becker, B., Molitor, P.: Technische Informatik : eine einführende Darstellung. München, Wien : Oldenbourg, 2008.

Hoffmann, D. W.: Grundlagen der Technischen Informatik. München: Hanser, 2007.

Balzert, H.: Lehrbuch Grundlagen der Informatik : Konzepte und Notationen in UML, Java und C++, Algorithmik und Software-Technik, Anwendungen. Heidelberg, Berlin : Spektrum, Akad. Verl., 1999.

Trauboth, H.: Software-Qualitätssicherung : konstruktive und analytische Maßnahmen. München, Wien : Oldenbourg, 1993.
Ada Reference Manual, ISO/IEC 8652:2012(E), Language and Standard Libraries. Springer Heidelberg

Benra, J.; Keller, H.B.; Schiedermeier, G.; Tempelmeier, T.: Synchronisation und Konsistenz in Echtzeitsystemen. Benra, J.T. [Hrsg.] Software-Entwicklung für Echtzeitsysteme Berlin [u.a.] : Springer, 2009, S.49-65
Färber, G.:Prozeßrechentechnik. Springer-Lehrbuch. Springer; Auflage: 3., überarb. Aufl. (7. September 1994)
Leitfaden Informationssicherheit, IT-Grundschutz kompakt. Bundesamt für Sicherheit in der Informationstechnik – BSI53133 Bonn, 2012, BSI-Bro12/311
Cooling, J.: Software Engineering for Real Time Systems. Addison-Wesley, Pearson, Harlow, 2002.
Stallings, W.: Betriebssysteme. 4. Auflage. Pearson Studium, München, 2003.
Summerville, I.: Software Engineering. Pearson Studium, München, 2007.

Course: Integrated Information Systems for engineers [2121001]

Coordinators: J. Ovtcharova
Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT]

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

Learning Control / Examinations
Depending on choice according to acutal version of study regulations

Conditions
None

Recommendations
None

Learning Outcomes
Students can:

- illustrate the structure and operating mode of information systems
- explain different goals of specific IT systems in product development (CAD, CAP, CAM, PPS, ERP, PDM) and assign product development processes
- describe the fundamentals of knowledge management and its application in engineering and deploy ontology as knowledge representation
- describe different types of process modelling and their application and illustrate and execute simple work flows and processes with selected tools

Content

- Information systems, information management
- CAD, CAP and CAM systems
- PPS, ERP and PDM systems
- Knowledge management and ontology
- Process modeling

Literature
Lecture slides

Course: Vibration Theory [2161212]

Coordinators: A. Fidlin

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Production Technology (p. 60)[MSc-Modul PT, WPF PT], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
Written exam

Conditions
None.

Recommendations
Examen in Engineering Mechanics 3 + 4

Learning Outcomes
The course gives an introduction into the vibration theory of linear systems. First, general vibration in form of harmonic signals is considered. One degree of freedom systems are treated in detail for free and forced vibration, especially for harmonic, periodic and arbitrary excitation. This is the foundation for systems with many degrees of freedom as these may be transformed with the help of modal coordinates. For multiple dof systems the eigenvalue problem is solved. Then forced vibration is treated. Finally, wave propagation problems and eigenvalue problems for systems with distributed parameters are discussed. As an application an introduction into rotor dynamics is given.

Goal of the course is to see the similarities for systems with one dof and with multiple dof. Besides typical phenomena like resonance a systematic mathematical approach to vibration problems and an interpretation of the mathematical results should be obtained.

Content
Concept of vibration, superposition of vibration with equal and with different frequencies, complex frequency response.

Vibration of systems with one dof: Free undamped and damped vibration, forced vibration for harmonic, periodic and arbitrary excitation. Excitation of undamped vibration in resonance.

Systems with many degrees of freedom: Eigenvalue problem for undamped vibration, orthogonality of eigenvectors, modal decoupling, approximation methods, eigenvalue problem for damped vibration. Forced vibration for harmonic excitation, modal decomposition for arbitrary forced vibration, vibration absorber.

Vibration of systems with distributed parameters: Partial differential equations as equations of motion, wave propagation, d'Alembert's solution, Ansatz for separation of time and space, eigenvalue problem, infinite number of eigenvalues and eigenfunctions.

Introduction to rotor dynamics: Laval rotor in rigid and elastic bearings, inner damping, Laval rotor in anisotropic bearings, synchronous and asynchronous whirl, rotors with asymmetric shaft.

Literature
Klotter: Technische Schwingungslehre, Bd. 1 Teil A, Heidelberg, 1978

Hagedorn, Otterbein: Technische Schwingungslehre, Bd 1 and Bd 2, Berlin, 1987

Wittenburg: Schwingungslehre, Springer-Verlag, Berlin, 1995

Course: Technical Design in Product Development [2146179]

Coordinators: M. Schmid
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
For the reason of high student number the exam is a written exam.
Only dictionnary is allowed.

Conditions
none

Recommendations
None

Learning Outcomes
In the Technical Design module, at the end of the lecture, students acquire knowledge of the essential basics of technically oriented design as an integral part of methodological product development. A strong focus is on the user-centered design of the man-machine interface as the basis for a holistic product design.
The students have knowledge about ...

- acquire well-founded design knowledge for use at the interface between engineer and designer
- acquire knowledge about the integration of design into the design development process.
- acquire all relevant human-product requirements that are derived from the bidirectional information flow between man and machine.
- master evaluation processes with regard to solution-independent fixed, divisional and desired requirements and their different weighting to determine usability factors in the context of the product.
- acquire a better understanding of the transfer of theoretical knowledge into practical product designs using a consistent example.

Content
preface
Value-relevant parameters of the technical design
Interface Design Basics
Macroergonomics: Planning and concept phase
Microergonomics: concept and design phase
Microergonomics: Development phase
best practice

Literature
Inhalt:
Einleitung
Wertrelevante Parameter des Technischen Design
Grundlagen Interface-Design
Makroergonomie: Planung- u. Konzeptphase
Mikroergonomie: Konzept- u. Entwurfsphase
Mikroergonomie: Ausarbeitungsphase
Best Practice
Literatur:
Markus Schmid, Thomas Maier
Technisches Interface Design
Anforderungen, Bewertung, Gestaltung.
Springer Vieweg Verlag

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Industrial Design Engineering.
2. , bearb. und erweiterte Auflage.
Springer-Verlag GmbH
ISBN: 3540236538
September 2005 - gebunden - 396 Seiten

Course: Technology of steel components [2174579]

Coordinators: V. Schulze
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
Materials Science I & II

Learning Outcomes
The students have the background to evaluate the influence of manufacture processes on the compound state of metallic compounds. The students can assess the influence and the stability of compound state under mechanical load. The students are capable to describe the individual aspects of interaction of the compound state of steel components due to forming, heat treatment, mechanical surface treatment and joining processes.

Content
Meaning, Development and characterization of component states
Description of the influence of component state on mechanical properties
Stability of component states
Steel manufacturing
Component states due to forming
Component states due to heat treatments
Component states due to surface hardening
Component states due to machining
Component states due to mechanical surface treatments
Component states due to joining
Summarizing evaluation

Literature
Script will be distributed within the lecture
VDEh: Werkstoffkunde Stahl, Bd. 1: Grundlagen, Springer-Verlag, 1984
H.-J. Eckstein: Technologie der Wärmebehandlung von Stahl, Deutscher Verlag Grundstoffindustrie, 1977
H.K.D.H. Badeshia, R.W.K. Honeycombe, Steels - Microstructure and Properties, CIMA Publishing, 3. Auflage, 2006
V. Schulze: Modern Mechanical Surface Treatments, Wiley, Weinheim, 2005

Course: Ten lectures on turbulence [2189904]

Coordinators: I. Otic
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination; duration: 20 minutes

Conditions
None.

Recommendations

- Undergraduate statistics and probability theory. Graduate-level fluid mechanics.

Learning Outcomes
At the completion of this course, students
- are able to understand fundamentals of statistical fluid mechanics, turbulence theory and turbulence modelling
- are able to derive RANS and LES transport equations
- get working knowledge of modelling techniques that can be used for solving engineering heat and mass transfer problems.

Content
The course is aimed of giving the fundamentals of turbelence theory, modelling and simulation. Governing equations and statistical description of turbulence are introduced. Reynolds equations, Kolmogorov's theory and scales of turbulent ows are discussed. Homogeneous and isotropic turbulence. Turbulent free-shear ows and wall-bounded turbulent ows are discussed. Turbulence modelling approaches and simulation methods are introduced.

Literature
Reference texts:
- Lecture Notes
- Presentation slides
Recommended Books:
- Pope, S. B.: Turbulent Flows. Cambridge University Press , 2003.
- Hinze J. O.: Turbulence. McGraw-Hill, 1975.

Course: Materials under high thermal or neutron loads [2194650]

Coordinators: A. Möslang, J. Reiser
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral Examination (20 min)

Conditions
Materials science I

Recommendations
none

Learning Outcomes
Advanced structural and functional materials for thermally or neutronically highly loaded systems. The students learn property profiles, applications and the interaction between atomic structure, microstructure and macroscopic materials behaviour.

Content
- Introduction and basics
- Metallic and ceramic solid state structure
- Transport of mater and conversion in solid state
- Material properties at high heat leoads
- Interaction between energetic particles and condensed matter, irradiation damage
- Nanoscaled modelling of damage relevant properties
- State-of-the-art analytical methods with particles
- Highly heat resistant Steels
- Nanoscaled, oxide dispersion strengthened alloys
- Super alloys
- Refractory metals and laminates
- Fibre reinforced structural ceramics
- Light high strength Beryllium alloys
- Oxides and functional materials
- Joining technologies
- Strategies of materials development
- Applications in Fusion, fission, large scale accelerators and concentrated solar power

Literature
Presentation with figures and tables, Exercise sheets

Course: Computational methods for the heat protection of a full vehicle [2157445]

Coordinators: H. Reister
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
This cours is no longer offered.

Conditions
None.

Recommendations
basics in fluid mechanics and thermodynamics recommended

Learning Outcomes
The students have basic equations to understand thermal situation in vehicles.
They can evaluate thermal situation in vehicles.
The students can utilize methods.

Content
In the lecture computational methods for the heat protection of the full vehicle are presented. For this the basic conservation equations are introduced and the applied computational programs are discussed in detail. The aspects concerning fluid mechanics are treated extensively. For this the underhood flow as well as the flow around the vehicle, at the underbody and at the rear of the car are considered. The computation of the temperature in the components of the vehicle is illustrated. For this mainly local approaches for the classical and electronic components are used. Finally a new overall approach for the heat protection is exlpained whre also detailed compuations at the engine, at the exhaust system and at the transmission are integrated.
Content
1. Introduction
2. Theoretical fundamentals
3. Computational methods
4. Numerical simulation of the flow in and around the vehicle
5. Computation of the temperature in components
6. Overall approach for the hat protection

Course: Thermal Solar Energy [2169472]

Coordinators: R. Stieglitz
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Duration: approximately 25 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
desirbale are reliable knowledge in physics in optics and thermodynamics
Basics in heat and mass transfer, material science, energy technology and fluid mechanics

Learning Outcomes
The lecture elaborates the basics of the solar technology and the definition of the major wordings and its phyical content such as radiation, thermal use, insulation etc.. Further the design of solar collectors for different purposes is discussed and analyzed. The functional principle of solar plants is elaborated before at the ende the ways for solar climatization is discussed.
The aim of the course is to provide the basic physical principles and the derivation of key parameters for the individual solar thermal use. This involves in addition to the selective absorber, mirrors, glasses, and storage technology. In addition, a utilization of solar thermal energy means an interlink of the collector with a thermal-hydraulic circuit and a storage. The goal is to capture the regularities of linking to derive efficiency correlations as a function of their use and evaluate the performance of the entire system.

Content
Baiscs of thermal solar energy (radiation, heat conduction, storage, efficiency ....) Active and passive use of solar energy. Solar collectors (design types, efficiency, system technology). Solar plants (heliostats etc.). Solar climatization.
In detail:

1 Introduction to energy requirements and evaluation of the potential use of solar thermal energy.

2 Primary energy sources SUN: sun, solar constant, radiation (direct, diffuse scattering, absorption, impact angle, radiation balance).

3 Solar panels: schematic structure of a collector, fundamentals of efficiency, meaning of concentration and their limitations.

4 Passive solar mechanisms: heat conduction in solids and gases, radiation heat transfer in transparent and opaque bodies, selective absorber - typical materials and manufacturing processes.

5 Momentum and heat transport: basic equations of single and multiphase transport, calculation methods, stability limits.

optional

6 Low temperature solar thermal systems: Collector variants, methods for system simulation, planning and dimensioning of systems, system design and arrest scenarios.

6 High temperature solar thermal systems: solar towers and solar-farm concept, loss mechanisms, chimney power plants and energy production processes

end

- Memory: energy content, storage types, storage materials, cost
- Solar Air Conditioning: Cooling capacity determination, climate, solar cooling method and evaluation of air conditioning.

Media
Präsentation complemented by printouts

Literature
supply of lecture material in printed and electronic form
Stieglitz & Heinzel; Thermische Solarenergie -Grundlagen-Technologie- Anwendungen. Springer Vieweg Verlag. 711 Seiten. ISBN 978-3-642-29474-7

Course: Thermal Turbomachines I [2169453]

Coordinators: H. Bauer
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Duration: approximately 30 min

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Recommended in combination with the lecture 'Thermal Turbomachines II'.

Learning Outcomes
The students are able to explain and comment on the design and operation of thermal turbomachines in detail. Moreover, they can evaluate the range of applications for turbomachinery. Therefore, students are able to to describe and analyse not only the individual components but also entire assemblies. The students can asses and evaluate the effects of physical, economical and ecological boundary conditions.

Content
Basic concepts of thermal turbomachinery

Steam Turbines - Thermodynamic process analysis

Gas Turbines - Thermodynamic process analysis

Combined cycle and cogeneration processes

Overview of turbomachinery theory and kinematics

Energy transfer process within a turbine stage

Types of turbines (presented through examples)

1-D streamline analysis techniques

3-D flow fields and radial momentum equilibrium in turbines

Compressor stage analysis and future trends in turbomachinery

Literature
Lecture notes (available via Internet)

Bohl, W.: Strömungsmaschinen, Bd. I, II; Vogel Verlag, 1990, 1991

Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993

Traupel, W.: Thermische Turbomaschinen Bd. I, II, Springer-Verlag, 1977, 1982

Course: Thermal Turbomachines I (in English) [2169553]

Coordinators: H. Bauer
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)]

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

Learning Control / Examinations
oral
Duration: approximately 30 min

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Recommended in combination with the lecture 'Thermal Turbomachines II'.

Learning Outcomes
The students are able to explain and comment on the design and operation of thermal turbomachines in detail. Moreover, they can evaluate the range of applications for turbomachinery. Therefore, students are able to to describe and analyse not only the individual components but also entire assemblies. The students can asses and evaluate the effects of physical, economical and ecological boundary conditions.

Content
Basic concepts of thermal turbomachinery

Steam Turbines - Thermodynamic process analysis

Gas Turbines - Thermodynamic process analysis

Combined cycle and cogeneration processes

Overview of turbomachinery theory and kinematics

Energy transfer process within a turbine stage

Types of turbines (presented through examples)

1-D streamline analysis techniques

3-D flow fields and radial momentum equilibrium in turbines

Compressor stage analysis and future trends in turbomachinery

Literature
Lecture notes (available via Internet)

Bohl, W.: Strömungsmaschinen, Bd. I, II; Vogel Verlag, 1990, 1991

Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993

Traupel, W.: Thermische Turbomaschinen Bd. I, II, Springer-Verlag, 1977, 1982

Course: Thermal Turbomachines II [2170476]

Coordinators: H. Bauer
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	en

Learning Control / Examinations
oral examination

Conditions
None.

Recommendations
Recommended in combination with the lecture 'Thermal Turbomachines I'.

Learning Outcomes
Based on the fundamental skills learned in 'Thermal Turbomachines I' the students have the ability to design turbines and compressors and to analyse the operational behavior of these machines.

Content
General overview, trends in design and development

Comparison turbine - compressor

Integrating resume of losses

Principal equations and correlations in turbine and compressor design, stage performance

Off-design performance of multi-stage turbomachines

Control system considerations for steam and gas turbines

Components of turbomachines

Critical components

Materials for turbine blades

Cooling methods for turbine blades (steam and air cooling methods)

Short overview of power plant operation

Combustion chamber and environmental issues

Literature
Lecture notes (Available via internet)
Bohl, W.: Strömungsmaschinen, Bd. I,II, Vogel Verlag 1990, 1991
Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993
Traupel, W.: Thermische Turbomaschinen, Bd. I,II, Springer-Verlag, 1977, 1982

Course: Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises) [2193002]

Coordinators: H. Seifert
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
5	2	Winter term	de

Learning Control / Examinations
Oral examination (30 min)

Conditions
Knowledge of the course “Solid State Reactions and Kinetics of Phase Transformations” (Franke)

Recommendations

- basic course in materials science and engineering
- basic course in mathematics
- physics or physical chemistry

Learning Outcomes
The students know the heterogeneous phase equilibria of binary, ternary and multicomponent materials systems. They can analyze the thermodynamic properties of multiphase engineering materials and their reactions with gas and liquid phases.

Content
1. Binary phase diagrams
2. Ternary phase diagrams
- Complete solubility
- Eutectic systems
- Peritectic systems
- Systems with transition reactions
- Systems with intermetallic phases
3. Thermodynamics of solution phases
4. Materials reactions involving pure condensed phases and a gaseous phase
5. Reaction equilibria in systems containing components in condensed solutions
6. Thermodynamics of multicomponent multiphase materials systems
7. Calculation of Phase Diagrams (CALPHAD)

Literature
1. Phase Equilibria, Phase Diagrams and Phase Transformations, Their Thermodynamic Basis; M. Hillert, University Press, Cambridge (2007)
2. Introduction to the Thermodynamics of Materials; D.R. Gaskell, Taylor & Francis (2008)

Course: Thermal-Fluid-Dynamics [2189423]

Coordinators: S. Ruck
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The objectives of the lecture are the fundamentals of thermal-hydraulics for describing and evaluating convective turbulent transport processes as occurring in power engineering components. The major objective is a description of the convective heat transfer for external and internal flows. A central point is the transfer of analytic models to "state of the art" computational tools and the corresponding validation by advanced experimental methods. Beyond the superior goals the students shall be enabled (a) to develop differential equation of thermal-hydraulic transport and evolve dimensionless parameters (b) to transfer a real problem to an experimental or numerical model (c) to develop analogies and correlations for heat transfer processes of forced convection, (d) to select adequate computational methods/models and (e) to evaluate and select experiments including measurement techniques with adequate instrumentation for thermal-hydraulic problems.

Content
The lecture provides an overview of momentum and energy transport as occurring in power engineering components and heat exchangers. Conservation equations are discussed. Based on the fundamentals of thermal-hydraulics, dimensionless parameters for forced and free convection are evolved. The statistical concepts for describing turbulent flows and the corresponding transport equations are introduced. Analysis of thermal and turbulent measurement signals are discussed.
Flows close to walls play a crucial role for the convective heat transfer and for heat exchanger components. Thus, the thermal boundary layer equations are introduced for the laminar and turbulent case. Velocity and temperature laws of the wall as a basis for analogies and models of computational tools are discussed; turbulence modelling and scale-resolving methods and their applicability for different conditions or heat transfer fluids are described in the following. Analogies and correlations for internal and external forced convection are developed by means of approximation concepts. Furthermore, design options to enhance the efficiency of heat exchangers are discussed. Solution strategies and best practical guidelines of the aforementioned methods are provided.
Main Issues

- Fundamentals of flows and heat transfer
- Dimensionless parameters of thermal fluid dynamics
- Statistic description and analytics of turbulent flows
- Thermal boundary layer equations
- Velocity and temperature laws in boundary layers
- Convective Heat transfer of external and internal flows
- Analogies (Prandtl-, von Kárman, Martinelli,. . .)
- Methods for enhancing heat transfer
- Strategies and methods for experimental and numerical investigation of thermal-hydraulics in R&D

Literature
Literatures are specified in the corresponding lectures. Teaching materials are provided online at http://ilias.studium.kit.edu. Hardcopy script for special topics during the lecture.

Course: Tractors [2113080]

Coordinators: M. Kremmer, M. Scherer
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place only after the winter semester. Re-examinations are offered solely during this examination period.

Conditions
None.

Recommendations
basic knowledge in mechanical engineering

Learning Outcomes
After completion of the course the Students know:

- important problems in agritechnological developments
- Customer requirements and their implementation in tractors
- Tractor technology in width and depth

Content
Tractors are one of the most underestimated vehicles in regard to performance und technics. Almost none vehicle is as multifunctional and fullfilled with high-tec as a tractor. Automatic guidance, special chassis suspension or special concepts of power trains are one of the topics where tractors are in leading position in technologies

During the lecture an overview about the design and construction and application area is given. A close look will be taken on the historical backround, legal requirements, ways of development, agricultural organizations and the proces of development itself.

In detail the following topics will be dealt with:

- agricultural organization / legal requirements
- history of tractors
- tractor engineering
- tractor mechanics
- chassis suspension
- combustion engine
- transmission
- interfaces
- hydraulics
- wheels and tyres
- cabin
- electrics and electronics

Literature

- K.T. Renius: Traktoren - Technik und ihre Anwendung; DLG Verlag (Frankfurt), 1985
- E. Schilling: Landmaschinen - Lehr- und Handbuch für den Landmaschinenbau; Schilling-Verlag (Köln), 1960

Course: Turbine and compressor Design [2169462]

Coordinators: H. Bauer, A. Schulz
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
Thermal Turbomachines I+II

Learning Outcomes
The students have the ability to:

- describe special types of components, such as e.g. radial machines and transonic compressors
- explain and evaluate the operation of components and machines
- interpret and apply the the physical principles
- design individual components in a practical approach

Content
The lecture is intended to expand the knowledge from Thermal Turbomachines I+II.
Thermal Turbomaschines, general overview

Design of a turbomachine: Criteria and development

Radial machines

Transonic compressors

Combustion chambers

Multi-spool installations

Literature
Münzberg, H.G.: Gasturbinen - Betriebsverhalten und Optimierung, Springer Verlag, 1977

Traupel, W.: Thermische Turbomaschinen, Bd. I-II, Springer Verlang, 1977, 1982

Course: Turbo Jet Engines [2170478]

Coordinators: H. Bauer, A. Schulz
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes
The students have the ability to:

- compare the design concepts of modern jet engines
- analyse the operation of modern jet engines
- apply the thermodynamic and fluidmechanic basics of jet engines
- choose the main components intake, compressor, combustor, turbine and thrust nozzle based on given criteria
- comment on different methods for the reduction of pollutant emissions, noise and fuel consumption

Content
Introduction to jet engines and their components

Demands on engines and propulsive efficiency

Thermodynamic and gas dynamic fundamentals and design calculations

Components of air breathing engines

Jet engine design and development process

Engine and component design

Current developments in the jet engines industry

Literature
Hagen, H.: Fluggasturbinen und ihre Leistungen, G. Braun Verlag, 1982
Hünnecke, K.: Flugtriebwerke, ihre Technik und Funktion, Motorbuch Verlag, 1993
Saravanamuttoo, H.; Rogers, G.; Cohen, H.: Gas Turbine Theory, 5th Ed., 04/2001
Rolls-Royce: The Jet Engine, ISBN:0902121235, 2005

Course: Metal Forming [2150681]

Coordinators: T. Herlan
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students

- are able to reflect the basics, forming processes, tools, Machines and equipment of metal forming in an integrated and systematic way.
- are capable to illustrate the differences between the forming processes, tools, machines and equipment with concrete examples and are qualified to analyze and assess them in terms of their suitability for the particular application.
- are also able to transfer and apply the acquired knowledge to other metal forming problems.

Content
At the beginning of the lecture the basics of metal forming are briefly introduced. The focus of the lecture is on massive forming (forging, extrusion, rolling) and sheet forming (car body forming, deep drawing, stretch drawing). This includes the systematic treatment of the appropriate metal forming Machines and the corresponding tool technology.
Aspects of tribology, as well as basics in material science and aspects of production planning are also discussed briefly. The plastic theory is presented to the extent necessary in order to present the numerical simulation method and the FEM computation of forming processes or tool design. The lecture will be completed by product samples from the forming technology.
The topics are as follows:

- Introduction and basics
- Hot forming
- Metal forming machines
- Tools
- Metallographic fundamentals
- Plastic theory
- Tribology
- Sheet forming
- Extrusion
- Numerical simulation

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Combustion diagnositics [2167048]

Coordinators: R. Schießl, U. Maas
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
None

Learning Outcomes
After completing this course students can:

- understand the specific requirements for diagnostic techniques in combustion applications.
- explain the physical fundamentals of diagnostic techniques, in particular of laser diagnostics.
- assess the potentials and the limits of the different diagnositc methods.

Content
Diagnostical methods: Laser induced fluorescence, Rayleigh-scattering, Raman-scattering Chemoluminescence.
Reduced description of combustion processes and measurements.
Discussion of the potential and limits of specific strategies in different combustion systems.

Literature
Lecture notes
A.C. Eckbreth, Laser Diagnostics for Combustion Temperature and Species, Abacus Press, 2nd ed. (1996)
W. Demtröder, Laser Spectroscopy: Basic Concepts and Instrumentation, Springer, 3rd ed., 2003
Hollas J.M. Modern Spectroscopy, Wiley, 3rd ed., 1996
K. Kohse-Höinghaus, J. B. Jeffries (ed.), Applied Combustion Diagnostics, Taylor and Francis
Atkins P., Paula, J., Physical Chemistry, 8th ed., Oxford University Press, 2006

Course: Behaviour Generation for Vehicles [2138336]

Coordinators: C. Stiller, M. Werling
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
written examination

Conditions
none

Recommendations
Fundamentals in measurement, system and control theory, e.g. from the lecture "Measurement and Control Systems"

Learning Outcomes
Modern vehicle control systems like ABS or ESP transform the intention of the driver into a corresponding behaviour of the vehicle. This is achieved by compensating disturbances like a varying traction for example. Within the recent years, vehicles have been increasingly equipped with sensors that gather information about the environment (Radar, Lidar and Video for example). This enables the vehicles to generate an 'intelligent' behaviour and transform this behaviour into control signals for actors. Several so called 'driver assistance systems' have already achieved remarkable improvements as far as comfort, safety and efficiency are concerned. But nevertheless, several decades of research will be required to achieve an automated behaviour with a performance equivalent to a human operator ('the driver'). The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Information technology, control theory and kinematic aspects are treated to provide a broad overview over vehicle guidance. Application examples from cutting-edge and future driver assistance systems illustrate the discussed subjects.

Content
1. Driver assistance systems
2. Driving comfort and safety
3. Vehicle dynamics
4. Path and trajectory planning
5. Path control
6. Collision avoidance

Literature
TBA

Course: Failure of Structural Materials: Fatigue and Creep [2181715]

Coordinators: P. Gruber, P. Gumbsch, O. Kraft
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam ca. 30 minutes
no tools or reference materials

Conditions
none

Recommendations
preliminary knowlegde in mathematics, mechanics and materials science

Learning Outcomes
The student

- has the basic understanding of mechanical processes to explain the relationships between externally applied load and materials strength.
- can describe the main empirical materials models for fatigue and creep and can apply them.
- has the physical understanding to describe and explain phenomena of failure.
- can use statistical approaches for reliability predictions.
- can use its acquired skills, to select and develop materials for specific applications.

Content
1 Fatigue
1.1 Introduction
1.2 Statistical Aspects
1.3 Lifetime
1.4 Fatigue Mechanisms
1.5 Material Selection
1.6 Thermomechanical Loading
1.7 Notches and Shape Optimization
1.8 Case Study: ICE-Desaster

2 Creep
2.1 Introduction
2.2 High Temperature Plasticity
2.3 Phänomenological DEsciption of Creep
2.4 Creep Mechanisms
2.5 Alloying Effects

Literature

- Engineering Materials, M. Ashby and D.R. Jones (2nd Edition, Butterworth-Heinemann, Oxford, 1998); worth reading, relatively simple but comprehensive
- Mechanical Behavior of Materials, Thomas H. Courtney (2nd Edition, McGraw Hill, Singapur); classic on the mechanical behavior of materials, extensive and good
- Bruchvorgänge in metallischen Werkstoffen, D. Aurich (Werkstofftechnische Verlagsgesellschaft Karlsruhe), relatively simple but yet comprehensive overview of metallic materials
- Fatigue of Materials, Subra Suresh (2nd Edition, Cambridge University Press); standard work on fatigue, all classes of materials, extensive, for beginners and advanced student

Course: Failure of structural materials: deformation and fracture [2181711]

Coordinators: P. Gumbsch, D. Weygand, O. Kraft
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam ca. 30 minutes
no tools or reference materials

Conditions
none

Recommendations
preliminary knowlegde in mathematics, mechanics and materials science

Learning Outcomes
The student

- has the basic understanding of mechanical processes to explain the relationship between externally applied load and materials strength.
- can explain the foundation of linear elastic fracture mechanics and is able to determine if this concept can be applied to a failure by fracture.
- can decribe the main empirical materials models for deformation and fracture and can apply them.
- has the physical understanding to describe and explain phenomena of failure.

Content

1. Introduction
2. linear elasticity
3. classification of stresses
4. Failure due to plasticity
   - tensile test
   - dislocations
   - hardening mechanisms
   - guidelines for dimensioning
5. composite materials
6. fracture mechanics
   - hypotheses for failure
   - linear elasic fracture mechanics
   - crack resitance
   - experimental measurement of fracture toughness
   - defect measurement
   - crack propagation
   - application of fracture mechanics
   - atomistics of fracture

Exercises are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students.

Literature

- Engineering Materials, M. Ashby and D.R. Jones (2nd Edition, Butterworth-Heinemann, Oxford, 1998); worth reading, relatively simple but comprehensive
- Mechanical Behavior of Materials, Thomas H. Courtney (2nd Edition, McGraw Hill, Singapur); classic on the mechanical behavior of materials, extensive and good
- Bruchvorgänge in metallischen Werkstoffen, D. Aurich (Werkstofftechnische Verlagsgesellschaft Karlsruhe), relatively simple but yet comprehensive overview of metallic materials

Course: Gear Cutting Technology [2149655]

Coordinators: M. Klaiber
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
The assessment is carried out as an oral examination. The examination is offered every winter semester in agreement with the Lecturer.

Conditions
None

Recommendations
None

Learning Outcomes
The students ...

- can describe the basic terms of gearings and are able to explain the imparted basics of the gearwheel and gearing theory.
- are able to specify the different manufacturing processes and machine technologies for producing gearings. Furthermore they are able to explain the functional principles and the dis-/advantages of these manufacturing processes.
- can apply the basics of the gearing theory and manufacturing processes on new problems.
- are able to read and interpret measuring records for gearings.
- are able to make an appropriate selection of a process based on a given application
- can describe the entire process chain for the production of toothed components and their respective influence on the resulting workpiece properties.

Content
Based on the gearing theory, manufacturing processes and machine technologies for producing gearings, the needs of modern gear manufacturing will be discussed in the lecture. For this purpose, various processes for various gear types are taught which represent the state of the art in practice today. A classification in soft and hard machining and furthermore in cutting and non-cutting technologies will be made. For comprehensive understanding the processes, machine technologies, tools and applications of the manufacturing of gearings will be introduced and the current developments presented. For assessment and classification of the applications and the performance of the technologies, the methods of mass production and manufacturing defects will be discussed. Sample parts, reports from current developments in the field of research and an excursion to a gear manufacturing company round out the lecture.
The following topics will be covered:

- Sample applications
- Basics of gearing geometry
- Need of gearboxes
- Soft machining processes
- Hardening processes
- Hard machining processes
- Bevel gear production
- Measurement and testing

- Manufacturing of gearbox components
- Special gearings

Media
Lecture slides will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Slides

Remarks
None

Course: Virtual Engineering I [2121352]

Coordinators: J. Ovtcharova
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Writen examination 90 min. Masterstudents of Mechanical Engineering with "SP 28 Lifecycle Engineering" take an oral examination of 20 min of this core subject.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can:

- rename and explain the basic methods of virtual engineering and the typical problems in product development.
- associate the methods and problems of the corresponding phases of the product life cycle and derive the necessary interfaces.
- select the appropriate IT systems for given problems and evaluate their suitability for the support of management's approach PLM.
- apply CAD/CAx/PLM-Systems using simple exercises.

Content
The lecture presents the informational interrelationship required for understanding the virtual product development process. For this purpose, an emphasis and focus will be placed on IT-systems used in the industrial sector as support for the process chain of virtual engineering:

- Product Lifecycle Management refers to the entire lifecycle of the product, beginning with the concept phase up through disassembling and recycling.
- CAx-systems for the virtual product development allow the modeling of a digital product in regards to design, construction, manufacturing and maintenance.
- Validation Systems allow the checking of the product in regard to static, dynamics, safety and build ability.

The goal of the lecture is to clarify the relationship between construction and validation operations through the usage of virtual prototypes and VR/AR/MR visualisation techniques in connection with PDM/PLM-systems. This will be achieved through an introduction to each particular system along with praxis-oriented exercises.

Literature
Lecture slides

Course: Virtual Engineering II [2122378]

Coordinators: J. Ovtcharova
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Summer term	en

Learning Control / Examinations
Writen examination 90 min. Masterstudents of Mechanical Engineering with "SP 28 Lifecycle Engineering" take an oral examination of 20 min of this core subject.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students will be able to:

- describe virtual reality, how the stereoscopic effect occurs and compare the technologies to simulate this effect.
- describe how to model a scene in VR, store the VR graph on a computer and explain the inner workings of the VR pipeline for visualizing the scene.
- name various systems for interacting with the VR scene and assess the advantages and disadvantages of various manipulation and tracking devices.
- compare validation tests that can be carried through in the product development process with the aid of a virtual mock-up (VMU) and describe the difference between a VMU, a physical mock-up (PMU) and a virtual prototype (VP).
- point out the vision of an integrated virtual product development and which challenges need to be resolved towards that vision.

Content
The lecture presents the informational interrelationship required for understanding the virtual product development process. For this purpose, an emphasis and focus will be placed on IT-systems used in the industrial sector as support for the process chain of virtual engineering:

- The corresponding models can be visualized in Virtual Reality Systems, from single parts up through a complete assembly.
- Virtual Prototypes combine CAD-data as well as information about the remaining characteristics of the components and assembly groups for immersive visualisation, functionality tests and functional validations in the VR/AR/MR environment.
- Integrated Virtual Product Development explains exemplified the product development process from the point of view of Virtual Engineering.

The goal of the lecture is to clarify the relationship between construction and validation operations through the usage of virtual prototypes and VR/AR/MR visualisation techniques in connection with PDM/PLM-systems. This will be achieved through an introduction to each particular IT-system along with praxis-oriented exercises.

Literature
Lecture slides

Course: Heat and Mass Transfer [2165512]

Coordinators: U. Maas
Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Fundamentals and Methods of Product Development and Construction (p. 58)[MSc-Modul PEK, WPF PEK], Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of Energy and Environmental Engineering (p. 52)[MSc-Modul E+U, WPF E+U], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB]

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

Learning Control / Examinations
written (in winter- or summerterm)
duration: 3 hours
additives: non-progammable calculator, 2 DIN-A4-pages individual formulary

Conditions
Can not be combined with lecture 'Heat and Mass Transfer' [3122512].

Recommendations

- Lectures in Thermodynamics, Fluid Dynamics and Higher Mathematics
- Attendance of the tutorial (2165513 - Übungen zur Wärme- und Stoffübertragung)

Learning Outcomes
Students gain knowledge about the basic processes, principles and analytical based calclulation methods of heat and mass transfer. For this purpose application systems are used to exemplify the basic processes. These application systems serve as a link to industrial relevant sectors in mechanical engineering, energy and process enngineering. The students can delve their knowledge in accompanying tutorials and consulting hours.

Content

- Steade stade and non-stready heat transfer in homogenous and compound materials; Plates, pipe sections and sperical shells
- Diffusion in gases; analogies between heat conduction and mass diffusion
- Convective, forced heatr transmission in passed through pipes/channesl and circulated around plate and profiles.
- Convective mass transfer, heat-/mass transfer analogy
- Multi phase convective heat transmission (ceondensation, evaporation)
- radiative transfer of solid bodies and gases

Media
Blackboard and PowerPoint

Literature

- Maas ; Vorlesungsskript "Wärme- und Stoffübertragung"
- Baehr, H.-D., Stephan, K.: "Wärme- und Stoffübertragung" , Springer Verlag, 1993
- Incropera, F., DeWitt, F.: "Fundamentals of Heat and Mass Transfer" , John Wiley & Sons, 1996
- Bird, R., Stewart, W., Lightfoot, E.: "Transport Phenomena" , John Wiley & Sons, 1960

Course: Heatpumps [2166534]

Coordinators: H. Wirbser, U. Maas
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
None

Learning Outcomes
The attendance of this course enables students to:

- describe the setup and the working principle of heat pumps.
- specify the various types of heat pumps.
- analyse the energetic requirements.
- asses the advantages and drawbacks of heat pumps as heating system.

Content
The aim of this lecture is to promote heat pumps as heating systems for small an medium scale facilities and to discuss their advantages as well as their drawbacks. After considering the actual energy situation and the political requirements the different aspects of heat pumps are elucidated. The requirements concerning heat sources, the different components and the various types of heat pumps are discussed. In addition ecological and economical aspects are taken into consideration. The coupling of heat pumps with heat accumulators in heating systems will also be part of the lecture.

Literature
Vorlesungsunterlagen
Bach, K.: Wärmepumpen, Bd. 26 Kontakt und Studium, Lexika Verlag, 1979
Kirn, H., Hadenfeldt, H.: Wärmepumpen, Bd. 1: Einführung und Grundlagen, Verlag C. F. Müller, 1987
von Cube, H.L.: Lehrbuch der Kältetechnik, Verlag C.F. Müller, Karlsruhe, 1975.
von Cube, H.L., Steimle,F.: Wärmepumpen, Grunglagen und Praxis VDI-Verlag, Düsseldorf, 1978.

Course: Heat Transfer in Nuclear Reactors [2189907]

Coordinators: X. Cheng
Part of the modules: Lectures in English (M.Sc.) (p. 402)[Englischsprachige Veranstaltungen (M.Sc.)], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral examination; duration: 20 minutes

Conditions
None.

Learning Outcomes
This lecture is focused on students of mechanical engineering and chemical engineering in bachelor or master degree courses. The students learn some important processes and analysis methods of flow and heat transfer in nuclear reactors. After the lecture the students are capable of carrying out thermal-hydraulic analysis and making suggestions to improve the heat removal from the reactor core. Through the exercises with a specific numerical simulation programs the students will master the engineering procedure to perform thermal-hydraulic analysis of nuclear reactors.

Content

1. Overview of nuclear systems
2. Design tasks and design criteria of nuclear thermal-hydraulics
3. Heat release and distribution in nuclear reactors
4. Heat transfer process in nuclear reactors
5. Temperature distribution in coolant and structural materials
6. Pressure drops in nuclear systems
7. Flow stability of nuclear systems
8. Critical flow under accident conditions
9. Natural circulation and passive safety systems
10. Methodologies of thermal-hydraulic design

Literature

1. W. Oldekop, Einführung in die Kernreaktor und Kernkraftwerkstechnik, Verlag Karl Thiemig, München, 1975
2. L.S. Tong, J. Weisman, Thermal-hydraulics of pressurized water reactors, American Nuclear Society, La Grande Park, Illinois, USA
3. R.T. Lahey, F.J. Moody, The Thermal-Hydraulics of a Boiling Water Nuclear Reactor, 2nd edition, ANS, La Grande Park, Illinois, USA, 1993

Course: Probability Theory and Statistics [0186000]

Coordinators: D. Hug

Part of the modules: Fundamentals and Methods of Mechatronics and Microsystem Technology (p. 56)[MSc-Modul M+M, WPF M+M], Mathematical Methods (p. 32)[MSc-Modul 08, MM], Fundamentals and Methods of Automotive Engineering (p. 54)[MSc-Modul FzgT, WPF FzgT], Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM]

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

Learning Control / Examinations
written exam

Conditions
None.

Learning Outcomes
Students
- know the basic descriptive measures of distributions, and they are able to compute these in simple examples
- know the basic probabilistic models, concepts and methods, and they can apply these in simple examples
- know basic ideas of statistical inference, and they can set up estimators and confidence intervals in simple cases

Content
This course provides an introduction to basic concepts, methods and procedures in probability theory and statistics. It starts with descriptive statistics, explains the foundations of probability theory and treats statistical inference towards the end. Probability theory develops and applies mathematical models for phenomena of the real world that involve randomness, which are also of interest in their own right.
Probability theory constitutes the main part of the course. The task of descriptive statistics is to describe, order and collect data which arise from experiments. A presentation of these data can be given, for instance, by means of graphics or statistical characteristics (arithmetic mean, median, empirical variance etc.). Statistical inference is concerned with exploring in how far specific results of experiments are valid in greater generality, hence with inference from real data.

Content: Descriptive statistics
Events
Probability Spaces
Elements of Combinatorial Theory
Random Variables and their Distributions (discrete and continuous)
Conditional probability
Stochastic Independence
Descriptive Measures of Distributions
Generating Function and Laplace-Transform
Limit Theorems
Random Numbers and Simulation
Basic Problems of Statistics
Point Estimation
Confidence Regions
Statistical Tests

Course: Hydrogen Technologies [2170495]

Coordinators: T. Jordan
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

Auxiliary:no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes
The course content is the cross-cutting issue of hydrogen as energy carrier. After successful participation the students may reflect on the fundamental technological basis of an energy system using predominantly hydrogen as an energy carrier or energy storage. Based on this knowledge they may objectify the principle idea of an hydrogen economy.
The students know the fundamental physical and chemical properties of hydrogen and may apply their knowledge on thermodynamics to compare efficiencies of different solutions with hydrogen. They can list, compare and evaluate established and future solutions for production, storage and distribution of hydrogen. They can explain advantages and disadvantages of using hydrogen in conventional combustion processes versus using hydrogen in different fuel cells. In particular the can describe the specific safety aspects related to hydrogen, compare them with other energy vectors and evaluate different measures for risk mitigation.

Content
Basic concepts
Production
Transport and storage
Application
Safety aspects

Literature
Ullmann's Encyclopedia of Industrial Chemistry
Hydrogen and Fuel Cells, Ed. S. Stolten, Wiley-VCH, 2010, ISBN 978-3-527-32711-9

Course: Wave Propagation [2161219]

Coordinators: W. Seemann
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral

30 minutes (optional subject), 20 minutes (major subject)

no means

Conditions
Vibration theory

Learning Outcomes
The course gives an introduction into wave propagation phenomena. This contains both one-dimensional continua (beams, rods, strings) as well as two- and three-dimensional continua. Initial condition problems are treated. Fundamental effects like phase velocity, group velocity or dispersion are explained. Wave propagation is used to show the limits of structural models like beams. In addition surface waves and acoustic waves are covered.

Content
Wave propagation in strings and rods, d'Alembert's solution, initial value problem, boundary conditions, excitation at the boundary, energy transport, wave propagation in beams, Bernoulli-Euler beams, group velocity, beams with changing cross-section, reflexion and transmission, Timoshenko beam theory, wave propagation in membranes and plates, acoustic waves, reflexion and refraction, spherical waves, s- and p-waves in elastic media, reflexion and transmission at bounding surfaces, surface waves

Literature
P. Hagedorn and A. Dasgupta: Vibration and waves in continuous mechanical systems. Wiley, 2007.

Course: Materials for Lightweight Construction [2174574]

Coordinators: K. Weidenmann
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
none

Recommendations
Werkstoffkunde I/II

Learning Outcomes
The students are able to describe the mechanisms of strength and stiffness that fundamentally act in different lightweight materials and to explain the underlying material science aspects against the background of lightweight materials design.

Content
Introduction
Constructive, production-orientied and material aspects of lightweight construction
Aluminium-based alloys
Aluminium wrought alloys
Aluminium cast alloys
Magnesium-based alloys
Magnesium wrought alloys
Magnesium cast alloys
Titanium-based alloys
Titanium wrought alloys
Titanium cast alloys
High-strength steels
High-strength structural steels,
Heat-treatable steels, press-hardening and hardenable steels
Composites - mainly PMC
Matrices
Reinforcements
Basic mechanical principles of composites
Hybrid composites
Special materials for lightweight design
Beryllium alloys
Metallic Glasses
Applications

Literature
Presentation slides and additional lecture notes are handed out during the lecture, additional literature recommendations given

Course: Materials modelling: dislocation based plasticy [2182740]

Coordinators: D. Weygand
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam ca. 30 minutes

Conditions
none

Recommendations
preliminary knowlegde in mathematics, physics and materials science

Learning Outcomes
The student

- has the basic understanding of the physical basics to describe dislocations and their interaction with point, line and area defects.
- can apply modelling approaches for dislocation based plasticity.
- can explain discrete methods for modelling of microstructural evolution processes.

Content
1. Introduction
2. elastic fields of dislocations
3. slip, crystallography
4. equations of motion of dislocations
a) fcc
b) bcc
5. interaction between dislocations
6. molecular dynamics
7. discrete dislocation dynamics
8. continuum description of dislocations

Literature

1. D. Hull and D.J. Bacon, Introduction to Dislocations, Oxford Pergamon 1994
2. W. Cai and W. Nix, Imperfections in Crystalline Solids, Cambridge University Press, 2016
3. J.P. Hirth and J. Lothe: Theory of dislocations, New York Wiley 1982. (oder 1968)
4. J. Friedel, Dislocations, Pergamon Oxford 1964.
5. V. Bulatov, W. Cai, Computer Simulations of Dislocations, Oxford University Press 2006
6. A.S. Argon, Strengthening mechanisms in crystal plasticity, Oxford materials.

Course: Scientific computing for Engineers [2181738]

Coordinators: D. Weygand, P. Gumbsch
Part of the modules: Fundamentals and Methods of Theoretical Foundations of Mechanical Engineering (p. 62)[MSc-Modul ThM, WPF ThM], Fundamentals and Methods of General Mechanical Engineering (p. 50)[MSc-Modul MB, WPF MB], Fundamentals and Methods of Materials and Structures for High Performance Systems (p. 64)[MSc-Modul W+S, WPF W+S], Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
Written exam (90 minutes)

Conditions
The lecture can not be combined with the lecture “Application of advanced programming languages in mechanical engineering” (2182735).

Learning Outcomes
The student can

- apply the programming language C^{++} for scientific computing in the field of materials science
- adapt programs for use on parallel platforms
- choose suitable numerical methods for the solution of differential equations.
- write scripts controlling simulations
- write script for data handling

Through the accompanying exercises the students are able to apply the content of the lecture.

Content
1. Introduction: why scientific computing
2. computer architectures
3. Introduction to Unix/Linux
4. Foundations of C++11
   - progamm organization
   - data types, operator, control structures
   - dynamic memory allocation
   - functions
   - class
   - OpenMP parallelization
   - C++11 standard
5. numeric /algorithms
   - finite differences
   - MD simulations: 2nd order differential equations
   - algorithms for particle simulations
   - solver for linear systems of eqns.
6. Scripts

- basics bash scripts
- python for data analysis

Exercises (2181739, 2 SWS) are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students and for testing progress in learning of the topics.

Media
Slides of lectures and execises.

Literature
programming language C++

1. C++: Einführung und professionelle Programmierung; U. Breymann, Hanser Verlag München
2. C++ and object-oriented numeric computing for Scientists and Engineers, Daoqui Yang, Springer Verlag.
3. The C++ Programming Language, Bjarne Stroustrup, Addison-Wesley
4. Die C++ Standardbibliothek, S. Kuhlins und M. Schader, Springer Verlag

numerical analysis

1. Numerical recipes in C++ / C / Fortran (90), Cambridge University Press
2. Numerische Mathematik, H.R. Schwarz, Teubner Stuttgart
3. Numerische Simulation in der Moleküldynamik, Griebel, Knapek, Zumbusch, Caglar, Springer Verlag

Course: ZAK lectures [2101010]

Coordinators: M. Heilmaier
Part of the modules: Key Qualifications (p. 46)[MSc-Modul, SQL]

ECTS Credits	Hours per week	Term	Instruction language
2			

Learning Control / Examinations
s. courses

Conditions
None.

Learning Outcomes
s. courses

Content
For details of conception and contents of the courses refer to www.zak.kit.edu/sq

Course: Ignition systems [2133125]

Coordinators: O. Toedter
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral exam 20 minutes

Conditions
None.

Learning Outcomes
The Student can name the ignition systems and describe the ignition processes. He can explain the interaction between ignition and combustion process.

Content

- Ignition process
- Spark ignition
- Spark ignition system design
- Limits of spark ignition
- New developments of spark ignition systems
- New and alternative spark systems

Course: Two-Phase Flow and Heat Transfer [2169470]

Coordinators: T. Schulenberg, M. Wörner
Part of the modules: Compulsory Elective Module Mechanical Engineering (p. 35)[MSc-Modul 04, WF]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Basics of fluid mechanics and thermodynamics are a mandatory requirement.

Learning Outcomes
The students can describe two-phase flows with heat transfer as phenomena occuring in steam generators and condensers (e.g. in power stations or refrigerators). They can distinguish different flow regimes and transitions and apply two-phase flow models. The students are qualified to explain the characteristics of different flow examples (e.g. pressure drop of two phase flows, pool boiling, forced convective boiling, condensation) and can analysze two-phase flow instabilities.

Content

- Examples for technical applications
- Definitions and averaging of two-phase flows
- Flow regimes and transitions
- Two-phase models
- Pressure drop of two phase flows
- Pool boiling
- Forced convective boiling
- Condensation
- Two-phase flow instabilities

Media
Power Point presentations
Excel analyses

Literature
lecture notes

4.2 Courses in English

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

Coordination: M. Heilmaier
Degree programme: Masterstudiengang Maschinenbau (M.Sc.)
Subject:

ECTS Credits	Cycle	Duration

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2113809	Automotive Engineering I (eng.) (p. 167)	4	W	8	F. Gauterin, M. Gießler
2581998	Basics of Liberalised Energy Markets (p. 88)	2/1	W	3	W. Fichtner
2130910	CFD for Power Engineering (p. 97)	2	S	4	I. Otic
22331	Chemical Fuels (p. 98)	2	S	4	S. Bajohr, G. Schaub
2306315	Electrical Machines (p. 124)	2	S	4	M. Doppelbauer
23376	Electric Power Transmission & Grid Control (p. 123)	3	W	6	T. Leibfried
23399	Electric Power Generation and Power Grid (p. 122)	2	W	3	B. Hoferer
2170490	Combined Cycle Power Plants (p. 158)	2	S	4	T. Schulenberg
2190490	Introduction to Neutron Cross Section Theory and Nuclear Data Generation (p. 197)	2	S	4	R. Dagan
2169461	Coal fired power plants (p. 99)	2	W	4	T. Schulenberg
2161224	Machine Dynamics (p. 223)	3	S	5	C. Proppe
2145186	Mechanical Design I (p. 225)	4	W	4	A. Albers, N. Burkardt
23388	Modern Software Tools in Power Engineering (p. 260)	3	S	6	T. Leibfried
2189920	Nuclear Fusion Technology (p. 273)	2	W	4	A. Badea
2189921	Nuclear Power and Reactor Technology (p. 274)	3	W	6	A. Badea
2189904	Ten lectures on turbulence (p. 366)	2	W	4	I. Otic
2170476	Thermal Turbomachines II (p. 373)	3	S	6	H. Bauer
23682	Superconducting Materials for Energy Applications (p. 349)	2	S	3	F. Grilli
2114856	Vehicle Ride Comfort & Acoustics I (eng.) (p. 142)	2	S	4	F. Gauterin
2114857	Vehicle Ride Comfort & Acoustics II (eng.) (p. 144)	2	S	4	F. Gauterin
2189907	Heat Transfer in Nuclear Reactors (p. 391)	2	W	4	X. Cheng
2181740	Atomistic simulations and molecular dynamics (p. 75)	2	S	4	C. Brandl, P. Gumbsch
23716	Nanoscale Systems for Optoelectronics (p. 264)	2	S	3	H. Eisler
2169553	Thermal Turbomachines I (in English) (p. 372)	3	W	6	H. Bauer
2170460	Nuclear Power Plant Technology (p. 201)	2	S	4	T. Schulenberg, K. Litfin

2117059	Mathematical models and methods for Production Systems (p. 237)	4	W	6	K. Furmans, M. Rimmele
2142897	Microenergy Technologies (p. 250)	2	S	4	M. Kohl
2170491	Simulator Exercises Combined Cycle Power Plants (p. 337)	2	S	2	T. Schulenberg
2141861	Introduction to Microsystem Technology I (p. 172)	2	W	4	J. Korvink, V. Badilita, M. Jouda
2142874	Introduction to Microsystem Technology II (p. 174)	2	S	4	J. Korvink, M. Jouda
2169453	Thermal Turbomachines I (p. 371)	3	W	6	H. Bauer
2162344	Nonlinear Continuum Mechanics (p. 272)	2	S	5	T. Böhlke
2141501	Micro Magnetic Resonannce (p. 251)	2	W	4	J. Korvink, N. MacKinnon
2189404	A holistic approach to power plant management (p. 104)	2	W	4	M. Seidl, R. Stieglitz
2137308	Machine Vision (p. 219)	4	W	8	C. Stiller, M. Lauer
2189400	Solar Thermal Energy Systems (p. 339)	2	W	4	R. Dagan

Learning Control / Examinations

Conditions

None.

Learning Outcomes

Content

5 Major Fields

SP 01: Advanced Mechatronics

ID	Cat	Course	Lecturer	h	CP	Term
2106014	K	Data Analytics for Engineers (p. 522)	R. Mikut, M. Reischl, J. Stegmaier	3	5	S
2105011	K	Introduction into Mechatronics (p. 538)	M. Reischl, M. Lorch	3	6	W
2138326	K	Measurement II (p. 696)	C. Stiller	2	4	S
2162216	K	Computerized Multibody Dynamics (p. 776)	W. Seemann	2	4	S
2161219	K	Wave Propagation (p. 862)	W. Seemann	2	4	W
2141866	E	Actuators and sensors in nanotechnology (p. 470)	M. Kohl	2	4	W
2150904	E	Automated Manufacturing Systems (p. 496)	J. Fleischer	6	8	S
2138340	E	Automotive Vision (eng.) (p. 573)	C. Stiller, M. Lauer	3	6	S
2141864	E	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I (p. 506)	A. Guber	2	4	W
2142883	E	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II (p. 507)	A. Guber	2	4	S
2142879	E	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III (p. 508)	A. Guber	2	4	S
2147175	E	CAE-Workshop (p. 514)	A. Albers, Assistenten	3	4	W/S
2105016	E	Computational Intelligence (p. 521)	R. Mikut, W. Jakob, M. Reischl	2	4	W
2137309	E	Digital Control (p. 528)	M. Knoop	2	4	W
2113816	E	Vehicle Mechatronics I (p. 571)	D. Ammon	2	4	W
2105022	E	Information Processing in Mechatronic Systems (p. 636)	M. Kaufmann	2	4	W
2118183	E	IT-Fundamentals of Logistics (p. 646)	F. Thomas	2	4	S
2138341	E	Cogitive Automobiles - Laboratory (p. 653)	C. Stiller, M. Lauer	3	6	S
2146190	E	Lightweight Engineering Design (p. 657)	A. Albers, N. Burkardt	2	4	S
2137308	E	Machine Vision (p. 673)	C. Stiller, M. Lauer	4	8	W
2161206	E	Mathematical Methods in Dynamics (p. 683)	C. Proppe	2	5	W
2161254	E	Mathematical Methods in Strength of Materials (p. 684)	T. Böhlke	3	5	W
2181710	E	Mechanics in Microtechnology (p. 692)	P. Gruber, C. Greiner	2	4	W
24659	E	Human-Machine-Interaction (p. 694)	M. Beigl	2	3	S
2142897	E	Microenergy Technologies (p. 698)	M. Kohl	2	4	S
2142881	E	Microactuators (p. 701)	M. Kohl	2	4	S
2105024	E	Modern Control Concepts I (p. 709)	J. Matthes, L. Gröll	2	4	S
2106032	E	Modern Control Concepts II (p. 710)	L. Gröll, J. Matthes	2	4	W
2106035	E	Modern Control Concepts III (p. 711)	L. Gröll	2	4	S
2141865	E	Novel actuators and sensors (p. 717)	M. Kohl, M. Sommer	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2137306	E (P)	Lab Computer-aided methods for measurement and control (p. 747)	C. Stiller, M. Spindler	3	4	W
24152	E	Robotics I – Introduction to robotics (p. 782)	R. Dillmann, T. Asfour	2	6	W

ID	Cat	Course	Lecturer	h	CP	Term
23109	E	Signals and Systems (p. 796)	F. Puente, F. Puente León	2	6	W
2106033	E	System Integration in Micro- and Nanotechnology (p. 819)	U. Gengenbach	2	4	S
2138336	E	Behaviour Generation for Vehicles (p. 848)	C. Stiller, M. Werling	2	4	S
2133125	E	Ignition systems (p. 873)	O. Toedter	2	4	W
2150550	E (P)	Laboratory Production Metrology (p. 752)	B. Häfner	3	4	S
2105032	E	Micro- and nanosystem integration for medical, fluidic and optical applications (p. 700)	L. Koker, U. Gengenbach, I. Sieber	2	4	W

Conditions: only selectable for one of the following areas of specialization:

- Allgemeiner Maschinenbau
- Energie- und Umwelttechnik
- Fahrzeugtechnik
- Mechatronik und Mikrosystemtechnik
- Produktentwicklung und Konstruktion
- Produktionstechnik
- Theoretischer Maschinenbau

Recommendations: Recommended courses:

- 2105011 Einführung in die Mechatronik
- 2141861 Grundlagen der Mikrosystemtechnik I
- 2142874 Grundlagen der Mikrosystemtechnik II
- 2105014 Mechatronik-Praktikum

Learning Outcomes: The Advanced Mechatronics offers a broad, multidisciplinary body of knowledge. It qualifies graduates to solve essential mechatronic questions. In particular the following disciplines are covered by the major Advanced Mechatronics:

- Control theory
- Measurement technology and signal processing
- Mathematical methods

Students of the major Advanced Mechatronics know the future-oriented procedures. They are able to creatively solve complex interdisciplinary questions by applying the latest computer-assisted mathematical methods.
Remarks:

SP 02: Powertrain Systems

ID	Cat	Course	Lecturer	h	CP	Term
2113077	K	Drive Train of Mobile Machines (p. 475)	M. Geimer, M. Scherer, D. Engelmann	3	4	W
2146180	K	Powertrain Systems Technology A: Automotive Systems (p. 477)	A. Albers, S. Ott	2	4	S
2145150	K	Powertrain Systems Technology B: Stationary Machinery (p. 478)	A. Albers, S. Ott	2	4	W
2163111	K	Dynamics of the Automotive Drive Train (p. 532)	A. Fidlin	4	5	W
2145181	E	Applied Tribology in Industrial Product Development (p. 474)	A. Albers, B. Lorentz	2	4	W
2146208	E	Dimensioning and Optimization of Power Train System (p. 495)	H. Faust	2	4	S
2162235	E	Introduction into the multi-body dynamics (p. 539)	W. Seemann	3	5	S
2117500	E	Energy efficient intralogistic systems (p. 547)	M. Braun, F. Schönung	2	4	W
23321	E	Hybrid and Electric Vehicles (p. 626)	M. Doppelbauer, M. Schiefer	3	4	W
2118183	E	IT-Fundamentals of Logistics (p. 646)	F. Thomas	2	4	S
2145184	E	Leadership and Management Development (p. 664)	A. Ploch	2	4	W
2161224	E	Machine Dynamics (p. 677)	C. Proppe	3	5	S
2162220	E	Machine Dynamics II (p. 678)	C. Proppe	2	4	W
2141865	E	Novel actuators and sensors (p. 717)	M. Kohl, M. Sommer	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2113072	E	Development of Oil-Hydraulic Powertrain Systems (p. 766)	G. Geerling, S. Becker	2	4	W
2145182	E	Project management in Global Product Engineering Structures (p. 768)	P. Gutzmer	2	4	W
2150683	E	Control Technology (p. 806)	C. Gönnheimer	2	4	S
2146198	E	Strategic product development - identification of potentials of innovative products (p. 809)	A. Siebe	2	4	S
2146192	E	Sustainable Product Engineering (p. 818)	K. Ziegahn	2	4	S
2181114	E	Tribology (p. 839)	M. Dienwiebel	5	8	W
2133113	E	Combustion Engines I (p. 846)	H. Kubach, T. Koch	3	4	W
2181711	E	Failure of structural materials: deformation and fracture (p. 851)	P. Gumbsch, D. Weygand, O. Kraft	3	4	W

Conditions: In the Master's program only selectable for the following areas of specialization:

- Allgemeiner Maschinenbau
- Fahrzeugtechnik
- Produktentwicklung und Konstruktion
- Produktionstechnik

Recommendations: Recommended Courses:
2147175 CAE-Workshop
Learning Outcomes: The students know and understand the technical and physical basics and systematic connections of drive systems. The lecture deals vehicle drive systems as well as drive systems for stationary and mobile work machines.
They are able to choose, describe and use complex dimensioning- and design methods for drive systems under consideration of the interactions of the system.
Remarks:

SP 03: Man - Technology - Organisation

ID	Cat	Course	Lecturer	h	CP	Term
2109035	KP	Human Factors Engineering I: Ergonomics (p. 480)	B. Deml	2	4	W
2109036	KP	Human Factors Engineering II: Work Organisation (p. 481)	B. Deml	2	4	W
2110036	E	Human Factors Engineering III: Empirical research methods (p. 482)	B. Deml	2	4	S
2110050	E	Vehicle Ergonomics (p. 565)	T. Heine	2	4	S
2109021	E	Human-oriented Productivity Management: Personnel Management (p. 624)	P. Stock	2	4	W
2109042	E	Introduction to Industrial Production Economics (p. 631)	S. Dürrschnabel	2	4	W
2110037	E	Occupational Safety and Environmental Protection (in German) (p. 632)	R. von Kiparski	2	4	S
2145184	E	Leadership and Management Development (p. 664)	A. Ploch	2	4	W
2110017	E	Leadership and Conflict Management (in German) (p. 676)	H. Hatzl	2	4	S
2109034	E	Planning of Assembly Systems (in German) (p. 733)	E. Haller	2	4	W
2110032	E	Production Planning and Control (p. 759)	A. Rinn	2	4	W
2110046	E	Productivity Management in Production Systems (p. 762)	S. Stowasser	2	4	S
2117061	E	Safety Engineering (p. 795)	H. Kany	2	4	W
2146179	E	Technical Design in Product Development (p. 826)	M. Schmid	2	4	S

Conditions: only selectable for one of the following areas of specialization:

- Allgemeiner Maschinenbau
- Energie- und Umwelttechnik
- Produktentwicklung und Konstruktion
- Produktionstechnik

Recommendations:
Learning Outcomes: The students acquire a basic knowledge in the field of 1. ergonomics and 2. work organisation:

1. They are able to consider cognitive, physiological, anthropometric, and safety technical aspects in order to design workplaces ergonomically. Just as well they know physical and psycho-physical fundamentals (e. g. noise, lighting, climate) in the field of work-environmental design. Furthermore the students are able to evaluate workplaces by knowing and being able to apply essential methods of time studies and payment systems. Finally, they get a first, overall insight into the German labour law as well as into the organisation of advocacy groups beyond companies.
2. Within this module the students gain also a fundamental knowledge in the field of structural, process, and production organization. Besides, they get to know basic aspects of industrial teamwork and they know relevant theories in the field of interaction and communication, the management of employees as well as work satisfaction and motivation. Finally, the students get to know also methods in the field of personnel selection, development, and assessment.

Further on they get to know basic methods of behavioral-science data acquisition (e. g. eye-tracking, ECG, dual-task-paradigm) and they gain a first insight into empirical research methods (e. g. experimental design, statistical data evaluation). Selected complementary subjects deepen or extend the above mentioned learning outcomes.
Remarks:

SP 04: Automation Technology

ID	Cat	Course	Lecturer	h	CP	Term
2106005	K	Automation Systems (p. 498)	M. Kaufmann	2	4	S
2105016	K	Computational Intelligence (p. 521)	R. Mikut, W. Jakob, M. Reischl	2	4	W
2106014	K	Data Analytics for Engineers (p. 522)	R. Mikut, M. Reischl, J. Stegmaier	3	5	S
2137309	K	Digital Control (p. 528)	M. Knoop	2	4	W
2105011	K	Introduction into Mechatronics (p. 538)	M. Reischl, M. Lorch	3	6	W
2105024	K	Modern Control Concepts I (p. 709)	J. Matthes, L. Gröll	2	4	S
2150904	E	Automated Manufacturing Systems (p. 496)	J. Fleischer	6	8	S
2147175	E	CAE-Workshop (p. 514)	A. Albers, Assistenten	3	4	W/S
2113816	E	Vehicle Mechatronics I (p. 571)	D. Ammon	2	4	W
2137308	E	Machine Vision (p. 673)	C. Stiller, M. Lauer	4	8	W
2105014	E (P)	Laboratory mechatronics (p. 693)	C. Stiller, M. Lorch, W. Seemann	3	4	W
2138326	E	Measurement II (p. 696)	C. Stiller	2	4	S
2106032	E	Modern Control Concepts II (p. 710)	L. Gröll, J. Matthes	2	4	W
2106035	E	Modern Control Concepts III (p. 711)	L. Gröll	2	4	S
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2137306	E (P)	Lab Computer-aided methods for measurement and control (p. 747)	C. Stiller, M. Spindler	3	4	W
2105018	E	Simulation of Optical Systems (p. 800)	I. Sieber	2	4	W
2150683	E	Control Technology (p. 806)	C. Gönnheimer	2	4	S
2106033	E	System Integration in Micro- and Nanotechnology (p. 819)	U. Gengenbach	2	4	S
2138336	E	Behaviour Generation for Vehicles (p. 848)	C. Stiller, M. Werling	2	4	S
2123375	EM	Virtual Reality Laboratory (p. 858)	J. Ovtcharova	3	4	W/S
2161219	E	Wave Propagation (p. 862)	W. Seemann	2	4	W
2149902	E	Machine Tools and Industrial Handling (p. 867)	J. Fleischer	6	8	W
2150550	E (P)	Laboratory Production Metrology (p. 752)	B. Häfner	3	4	S
2105032	E	Micro- and nanosystem integration for medical, fluidic and optical applications (p. 700)	L. Koker, U. Gengenbach, I. Sieber	2	4	W

Conditions: only selectable for one of the following areas of specialization:

- Allgemeiner Maschinenbau
- Energie- und Umwelttechnik
- Fahrzeugtechnik
- Mechatronik und Mikrosystemtechnik
- Produktentwicklung und Konstruktion
- Produktionstechnik
- Theoretischer Maschinenbau

Recommendations:
Learning Outcomes: The Automation Engineering offers both theoretical foundations and practical knowledge in the field of automation. Students can select, apply and enhance existing methods. The main focus of the major is on

- Applied control engineering

- Automation
- Examples of field applications

Students of Automation Engineering are qualified to master complex challenges of the future. They are able to apply their profound knowledge and the future-oriented methods independent of a particular application field.
Remarks:

SP 06: Computational Mechanics

ID	Cat	Course	Lecturer	h	CP	Term
2153441	K	Numerical Fluid Mechanics (p. 726)	F. Magagnato	2	4	W
2162246	K	Computational Dynamics (p. 774)	C. Proppe	2	4	S
2161250	K	Computational Mechanics I (p. 777)	T. Böhlke, T. Langhoff	4	6	W
2182735	E	Application of advanced programming languages in mechanical engineering (p. 479)	D. Weygand	2	4	S
2181740	E	Atomistic simulations and molecular dynamics (p. 483)	C. Brandl, P. Gumbsch	2	4	S
2153405	E	Finite Difference Methods for numerial solution of thermal and fluid dynamical problems (p. 527)	C. Günther	2	4	W
2183716	E (P)	FEM Workshop – constitutive laws (p. 575)	K. Schulz, D. Weygand	2	4	W/S
2154431	E	Finite Volume Methods for Fluid Flow (p. 581)	C. Günther	2	4	S
2167523	E	Modeling of Thermodynamical Processes (p. 708)	R. Schießl, U. Maas	3	6	W/S
2130934	E	Numerical Modeling of Multiphase Flows (p. 723)	M. Wörner	2	4	S
2169458	E	Numerical simulation of reacting two phase flows (p. 724)	R. Koch	2	4	W
2153449	E	Numerical Simulation of Turbulent Flows (p. 725)	G. Grötzbach	3	4	W
2162256	E	Computational Vehicle Dynamics (p. 775)	C. Proppe	2	4	S
2162296	E	Computational Mechanics II (p. 778)	T. Böhlke, T. Langhoff	4	6	S

Conditions:
Recommendations:
Learning Outcomes: The module offers a wide interdisciplinary education of the students in the areas which are summarized internationally under the concept 'Computational Mechanics':

* Continuum modelling (in structural mechanics, material theory, dynamics, fluid mechanics and thermodynamics)
* Numerical mathematics
* Informatics

Students know the procedures oriented to the future of modern engineering. They have the ability for individual, creative solutions of complicated problems with numerical means and take into account the interaction with neighboring fields.
Remarks:

SP 10: Engineering Design

ID	Cat	Course	Lecturer	h	CP	Term
2146180	K	Powertrain Systems Technology A: Automotive Systems (p. 477)	A. Albers, S. Ott	2	4	S
2145150	K	Powertrain Systems Technology B: Stationary Machinery (p. 478)	A. Albers, S. Ott	2	4	W
2146190	K	Lightweight Engineering Design (p. 657)	A. Albers, N. Burkardt	2	4	S
2145181	E	Applied Tribology in Industrial Product Development (p. 474)	A. Albers, B. Lorentz	2	4	W
2113079	E	Design and Development of Mobile Machines (p. 494)	M. Geimer, J. Siebert	2	4	W
2113809	E	Automotive Engineering I (eng.) (p. 601)	F. Gauterin, M. Gießler	4	8	W
2147175	E	CAE-Workshop (p. 514)	A. Albers, Assistenten	3	4	W/S
2161229	EM	Designing with numerical methods in product development (p. 530)	E. Schnack	2	4	W
2110050	E	Vehicle Ergonomics (p. 565)	T. Heine	2	4	S
2149657	E	Manufacturing Technology (p. 577)	V. Schulze, F. Zanger	6	8	W
2113805	E	Automotive Engineering I (p. 600)	F. Gauterin, H. Unrau	4	8	W
2113814	E	Fundamentals for Design of Motor-Vehicles Bodies I (p. 616)	H. Bardehle	1	2	W
2114840	E	Fundamentals for Design of Motor-Vehicles Bodies II (p. 617)	H. Bardehle	1	2	S
2113812	E	Fundamentals in the Development of Commercial Vehicles I (p. 618)	J. Zürn	1	2	W
2114844	E	Fundamentals in the Development of Commercial Vehicles II (p. 619)	J. Zürn	1	2	S
2113810	E	Fundamentals of Automobile Development I (p. 620)	R. Frech	1	2	W
2114842	E	Fundamentals of Automobile Development II (p. 621)	R. Frech	1	2	S
2150601	E	Integrative Strategies in Production and Development of High Performance Cars (p. 641)	K. Schlichtenmayer	2	4	S
2174571	E	Design with Plastics (p. 656)	M. Liedel	2	4	S
2145184	E	Leadership and Management Development (p. 664)	A. Ploch	2	4	W
2110017	E	Leadership and Conflict Management (in German) (p. 676)	H. Hatzl	2	4	S
2105014	E (P)	Laboratory mechatronics (p. 693)	C. Stiller, M. Lorch, W. Seemann	3	4	W
2114860	E	Principles of Whole Vehicle Engineering II (p. 754)	R. Frech	1	2	S
2113072	E	Development of Oil-Hydraulic Powertrain Systems (p. 766)	G. Geerling, S. Becker	2	4	W
2145182	E	Project management in Global Product Engineering Structures (p. 768)	P. Gutzmer	2	4	W
2149667	E	Quality Management (p. 771)	G. Lanza	2	4	W
2117061	E	Safety Engineering (p. 795)	H. Kany	2	4	W
2146198	E	Strategic product development - identification of potentials of innovative products (p. 809)	A. Siebe	2	4	S
2146192	E	Sustainable Product Engineering (p. 818)	K. Ziegahn	2	4	S
2158107	E	Technical Acoustics (p. 820)	M. Gabi	2	4	S
2146179	E	Technical Design in Product Development (p. 826)	M. Schmid	2	4	S

ID	Cat	Course	Lecturer	h	CP	Term
2149902	E	Machine Tools and Industrial Handling (p. 867)	J. Fleischer	6	8	W

Conditions: The courses [2113805] and [2113809] can not be combined.
Recommendations: 2147175 CAE-Workshop
2105014 Mechatronik - Workshop
Learning Outcomes: The students are able to transfer their knowledge und abilities in product engineering to mechanical systems in research and industrial practice.
Remarks:

SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics

ID	Cat	Course	Lecturer	h	CP	Term
2113806	K	Vehicle Comfort and Acoustics I (p. 566)	F. Gauterin	2	4	W
2114825	K	Vehicle Comfort and Acoustics II (p. 568)	F. Gauterin	2	4	S
2158107	K	Technical Acoustics (p. 820)	M. Gabi	2	4	S
2114856	K	Vehicle Ride Comfort & Acoustics I (eng.) (p. 567)	F. Gauterin	2	4	S
2114857	K	Vehicle Ride Comfort & Acoustics II (eng.) (p. 569)	F. Gauterin	2	4	S
2146180	E	Powertrain Systems Technology A: Automotive Systems (p. 477)	A. Albers, S. Ott	2	4	S
2110050	E	Vehicle Ergonomics (p. 565)	T. Heine	2	4	S
2138340	E	Automotive Vision (eng.) (p. 573)	C. Stiller, M. Lauer	3	6	S
2163111	E	Dynamics of the Automotive Drive Train (p. 532)	A. Fidlin	4	5	W
2113807	E	Handling Characteristics of Motor Vehicles I (p. 563)	H. Unrau	2	4	W
2114838	E	Handling Characteristics of Motor Vehicles II (p. 564)	H. Unrau	2	4	S
2113816	E	Vehicle Mechatronics I (p. 571)	D. Ammon	2	4	W
2114835	E	Automotive Engineering II (p. 602)	H. Unrau	2	4	S
2153425	E	Industrial aerodynamics (p. 630)	T. Breitling, B. Frohnapfel	2	4	W
2146190	E	Lightweight Engineering Design (p. 657)	A. Albers, N. Burkardt	2	4	S
2105024	E	Modern Control Concepts I (p. 709)	J. Matthes, L. Gröll	2	4	S
2162246	E	Computational Dynamics (p. 774)	C. Proppe	2	4	S
2162256	E	Computational Vehicle Dynamics (p. 775)	C. Proppe	2	4	S
2162216	E	Computerized Multibody Dynamics (p. 776)	W. Seemann	2	4	S
2138336	E	Behaviour Generation for Vehicles (p. 848)	C. Stiller, M. Werling	2	4	S
2161219	E	Wave Propagation (p. 862)	W. Seemann	2	4	W

Conditions: The courses [2114835] and [2114855] can not be combined within this major field
The courses [2113806] and [2114856] can not be combined within this major field
The courses [2114825] and [2114857] can not be combined within this major field
Recommendations: Recommended courses:

- 2162235 Introduction into the multi-body dynamics
- 2161212 Vibration Theory

Learning Outcomes: The student
• knows and understands the dynamic characteristics of vehicles, owing to the construction and design tokens,
• knows and understands especially the factors being relevant for comfort and acoustics,
• is capable of fundamentally evaluating and rating handling characteristics.
Remarks:

SP 12: Automotive Technology

ID	Cat	Course	Lecturer	h	CP	Term
2113809	K	Automotive Engineering I (eng.) (p. 601)	F. Gauterin, M. Gießler	4	8	W
2113805	K	Automotive Engineering I (p. 600)	F. Gauterin, H. Unrau	4	8	W
2133132	E	Alternative Powertrain for Automobiles (p. 472)	K. Noreikat, H. Kubach	2	4	W
2146180	E	Powertrain Systems Technology A: Automotive Systems (p. 477)	A. Albers, S. Ott	2	4	S
2146208	E	Dimensioning and Optimization of Power Train System (p. 495)	H. Faust	2	4	S
2150904	E	Automated Manufacturing Systems (p. 496)	J. Fleischer	6	8	S
2163111	E	Dynamics of the Automotive Drive Train (p. 532)	A. Fidlin	4	5	W
2113807	E	Handling Characteristics of Motor Vehicles I (p. 563)	H. Unrau	2	4	W
2114838	E	Handling Characteristics of Motor Vehicles II (p. 564)	H. Unrau	2	4	S
2110050	E	Vehicle Ergonomics (p. 565)	T. Heine	2	4	S
2113806	E	Vehicle Comfort and Acoustics I (p. 566)	F. Gauterin	2	4	W
2114825	E	Vehicle Comfort and Acoustics II (p. 568)	F. Gauterin	2	4	S
2113102	E	Vehicle Lightweight design – Strategies, Concepts, Materials (p. 570)	F. Henning	2	4	W
2113816	E	Vehicle Mechatronics I (p. 571)	D. Ammon	2	4	W
2114845	E	Tires and Wheel Development for Passenger Cars (p. 572)	G. Leister	2	4	S
2138340	E	Automotive Vision (eng.) (p. 573)	C. Stiller, M. Lauer	3	6	S
2114053	E	Composite Manufacturing – Polymers, Fibers, Semi-Finished Products, Manufacturing Technologies (p. 574)	F. Henning	2	4	S
2114835	E	Automotive Engineering II (p. 602)	H. Unrau	2	4	S
2134138	E	Fundamentals of catalytic exhaust gas aftertreatment (p. 604)	E. Lox, H. Kubach, O. Deutschmann, J. Grunwaldt	2	4	S
2113814	E	Fundamentals for Design of Motor-Vehicles Bodies I (p. 616)	H. Bardehle	1	2	W
2114840	E	Fundamentals for Design of Motor-Vehicles Bodies II (p. 617)	H. Bardehle	1	2	S
2113812	E	Fundamentals in the Development of Commercial Vehicles I (p. 618)	J. Zürn	1	2	W
2114844	E	Fundamentals in the Development of Commercial Vehicles II (p. 619)	J. Zürn	1	2	S
2113810	E	Fundamentals of Automobile Development I (p. 620)	R. Frech	1	2	W
2114842	E	Fundamentals of Automobile Development II (p. 621)	R. Frech	1	2	S
23321	E	Hybrid and Electric Vehicles (p. 626)	M. Doppelbauer, M. Schiefer	3	4	W
2153425	E	Industrial aerodynamics (p. 630)	T. Breitling, B. Frohnapfel	2	4	W
2150601	E	Integrative Strategies in Production and Development of High Performance Cars (p. 641)	K. Schlichtenmayer	2	4	S
2146190	E	Lightweight Engineering Design (p. 657)	A. Albers, N. Burkardt	2	4	S
2115808	E (P)	Motor Vehicle Laboratory (p. 659)	M. Frey	2	4	W/S

ID	Cat	Course	Lecturer	h	CP	Term
2182642	E	Laser in automotive engineering (p. 663)	J. Schneider	2	4	S
2149669	E	Materials and Processes for Body Lightweight Construction in the Automotive Industry (p. 681)	D. Steegmüller, S. Kienzle	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2114860	E	Principles of Whole Vehicle Engineering II (p. 754)	R. Frech	1	2	S
2123364	E	Product, Process and Resource Integration in the Automotive Industry (p. 757)	S. Mbang	3	4	S
2115817	E	Project Workshop: Automotive Engineering (p. 764)	F. Gauterin, M. Gießler, M. Frey	3	6	W/S
2113072	E	Development of Oil-Hydraulic Powertrain Systems (p. 766)	G. Geerling, S. Becker	2	4	W
2145182	E	Project management in Global Product Engineering Structures (p. 768)	P. Gutzmer	2	4	W
2162256	E	Computational Vehicle Dynamics (p. 775)	C. Proppe	2	4	S
5012053	E	Seminar for Automobile and Traffic History (p. 794)	T. Meyer	2	4	W/S
2146198	E	Strategic product development - identification of potentials of innovative products (p. 809)	A. Siebe	2	4	S
2146192	E	Sustainable Product Engineering (p. 818)	K. Ziegahn	2	4	S
2114856	E	Vehicle Ride Comfort & Acoustics I (eng.) (p. 567)	F. Gauterin	2	4	S
2114857	E	Vehicle Ride Comfort & Acoustics II (eng.) (p. 569)	F. Gauterin	2	4	S
2133113	E	Combustion Engines I (p. 846)	H. Kubach, T. Koch	3	4	W
2138336	E	Behaviour Generation for Vehicles (p. 848)	C. Stiller, M. Werling	2	4	S
2149655	E	Gear Cutting Technology (p. 853)	M. Klaiber	2	4	W

Conditions: The courses [2113805] and [2113809] can not be combined
The courses [2114835] and [2114855] can not be combined
The courses [2113806] and [2114856] can not be combined
The courses [2114825] and [2114857] can not be combined
Recommendations:
Learning Outcomes: The student
• knows the most important components of a vehicle,
• knows and understands the functioning and the interaction of the individual components,
• knows the basics of dimensioning the components,
• knows and understands the procedures in automobile development,
• knows and understands the technical specifications at the development procedures,
• is aware of notable boundaries like legislation,
• is ready to analyze and judge vehicle concepts and to participate competently in the development of vehicles.
Remarks:

SP 15: Fundamentals of Energy Technology

ID	Cat	Course	Lecturer	h	CP	Term
2130927	KP	Fundamentals of Energy Technology (p. 599)	A. Badea, X. Cheng	5	8	S
2189903	K	Introduction to Nuclear Energy (p. 536)	X. Cheng	2	4	W
2166538	K	Fundamentals of Combustion II (p. 614)	U. Maas	2	4	S
2157432	K	Hydraulic Fluid Machinery (p. 628)	B. Pritz	4	8	S
2190411	E	Selected Problems of Applied Reactor Physics and Exercises (p. 491)	R. Dagan	2	4	S
2133108	EM	Fuels and Lubricants for Combustion Engines (p. 501)	B. Kehrwald, H. Kubach	2	4	W
2169459	EM (P)	CFD-Lab using Open Foam (p. 517)	R. Koch	3	4	W
2157444	EM (P)	Introduction to numerical fluid dynamics (p. 540)	B. Pritz	2	4	W
2117500	E	Energy efficient intralogistic systems (p. 547)	M. Braun, F. Schönung	2	4	W
2189487	E	Energy Storage and Network Integration (p. 549)	R. Stieglitz, W. Jaeger, Jäger, Noe	2	4	W
2129901	E	Energy Systems I: Renewable Energy (p. 551)	R. Dagan	3	6	W
2154200	E	Gasdynamics (p. 588)	F. Magagnato	2	4	W
2171487	E (P)	Laboratory Exercise in Energy Technology (p. 665)	H. Bauer, U. Maas, H. Wirbser	3	4	W/S
2134134	EM	Analysis tools for combustion diagnostics (p. 697)	J. Pfeil	2	4	S
2142897	E	Microenergy Technologies (p. 698)	M. Kohl	2	4	S
2169458	EM	Numerical simulation of reacting two phase flows (p. 724)	R. Koch	2	4	W
2153441	E	Numerical Fluid Mechanics (p. 726)	F. Magagnato	2	4	W
23737	E	Photovoltaics (p. 729)	M. Powalla	3	6	S
2189906	E	Physical and chemical principles of nuclear energy in view of reactor accidents and back-end of nuclear fuel cycle (p. 732)	R. Dagan, Dr. Volker Metz	1	2	W
2171488	E (P)	Workshop on computer-based flow measurement techniques (p. 750)	H. Bauer	3	4	W/S
2189400	E	Solar Thermal Energy Systems (p. 804)	R. Dagan	2	4	W
2189910	E	Flows and Heat Transfer in Energy Technology (p. 811)	X. Cheng	2	4	W
2146192	EM	Sustainable Product Engineering (p. 818)	K. Ziegahn	2	4	S
2158107	EM	Technical Acoustics (p. 820)	M. Gabi	2	4	S
2169472	E	Thermal Solar Energy (p. 831)	R. Stieglitz	2	4	W
2169453	EM	Thermal Turbomachines I (p. 833)	H. Bauer	3	6	W
2133113	EM	Combustion Engines I (p. 846)	H. Kubach, T. Koch	3	4	W
2157381	E	Windpower (p. 869)	N. Lewald	2	4	W

Conditions: None.
Recommendations: Recommended Course:

- 2165512 Heat- and Mass transfer

Learning Outcomes: After completion of SP 15 students are able:

- to describe the elements of an energy system and their complex interactions,
- to list different conventional energy sources and assess their static range,
- to name the fluctuating supply of renewable energies such as wind, solar radiation, ocean currents and tides etc. and describe its effects on the energy system,
- to assess the effects of external and internal economic, ecological and technical boundary conditions of energy systems and to derive approaches for an optimal mix of different energy technologies,

- to explain the operational principle of well-established power plants as well as of power plants based on renewable energies.

Remarks:

SP 18: Information Technology

ID	Cat	Course	Lecturer	h	CP	Term
2105016	K	Computational Intelligence (p. 521)	R. Mikut, W. Jakob, M. Reischl	2	4	W
2106014	K	Data Analytics for Engineers (p. 522)	R. Mikut, M. Reischl, J. Stegmaier	3	5	S
2137309	K	Digital Control (p. 528)	M. Knoop	2	4	W
2137308	K	Machine Vision (p. 673)	C. Stiller, M. Lauer	4	8	W
2138326	K	Measurement II (p. 696)	C. Stiller	2	4	S
2106002	K	Computer Engineering (p. 823)	M. Lorch, H. Keller	3	6	S
2138340	E	Automotive Vision (eng.) (p. 573)	C. Stiller, M. Lauer	3	6	S
2114092	E	BUS-Controls (p. 511)	M. Geimer	2	4	S
2118094	E	Information Systems in Logistics and Supply Chain Management (p. 635)	C. Kilger	2	4	S
2105022	E	Information Processing in Mechatronic Systems (p. 636)	M. Kaufmann	2	4	W
24102	E	Information Processing in Sensor Networks (p. 637)	U. Hanebeck, Christiof Chlebek	3	4	W
2118183	E	IT-Fundamentals of Logistics (p. 646)	F. Thomas	2	4	S
2105014	E (P)	Laboratory mechatronics (p. 693)	C. Stiller, M. Lorch, W. Seemann	3	4	W
2134137	E	Engine measurement techniques (p. 713)	S. Bernhardt	2	4	S
2137306	E (P)	Lab Computer-aided methods for measurement and control (p. 747)	C. Stiller, M. Spindler	3	4	W
2169550	E	Reliability Engineering 1 (p. 780)	A. Konnov	2	3	S
2150683	E	Control Technology (p. 806)	C. Gönnheimer	2	4	S
2138336	E	Behaviour Generation for Vehicles (p. 848)	C. Stiller, M. Werling	2	4	S

Conditions:
Recommendations:
Learning Outcomes: Students are able to

- explain fundamentals of information technology for given problems in mechanical engineering an mechatronics.
- explain major methods for acquisition, processing and exploitation of information in technical systems.
- outline and to explain alternative methods to determine and to represent measurement uncertainties and their propagation in technical systems.
- explain information filters and fusion methods and understand their application to given problems.

Remarks:

SP 19: Information Technology of Logistic Systems

ID	Cat	Course	Lecturer	h	CP	Term
2118094	K	Information Systems in Logistics and Supply Chain Management (p. 635)	C. Kilger	2	4	S
2118183	K	IT-Fundamentals of Logistics (p. 646)	F. Thomas	2	4	S
2118078	K	Logistics - organisation, design and control of logistic systems (p. 669)	K. Furmans	4	6	S
2138340	E	Automotive Vision (eng.) (p. 573)	C. Stiller, M. Lauer	3	6	S
2118097	E	Warehousing and distribution systems (p. 661)	K. Furmans	2	4	S
2117056	E	Airport logistics (p. 671)	A. Richter	2	4	W
2117062	E	Supply chain management (p. 817)	K. Alicke	4	6	W

Conditions: none
Recommendations: Recommended compulsory optional subjects:

- Basics of statistic and probability theory
- Simulation of production systems and processes
- Stochastics in Mecanical Engineering
- Integrated Information Systems for engineers
- Modelling and Simulation

Learning Outcomes: Students are able to:

- Describe and explain soft- and hardware for logistical systems including Supply-Chains,
- Choose control mechanisms and communication systems and describe their basic functions,
- Compare strength and weaknesses of different approaches and evaluate the fundamental suitability.

Remarks: none

SP 20: Integrated Product Development

ID	Cat	Course	Lecturer	h	CP	Term
2145156	KP	Integrated Product Development (p. 642)	A. Albers	8	16	W

Conditions: The participation in “Integrated Product Development” requires the concurrent participation in lectures (2145156), tutorials (2145157) and project work (2145300).
Due to organizational reasons, the number of participants is limited. Thus a selection has to be made. For registration to the selection process a standard form has to be used, that can be downloaded from IPEK hompage from april to july. The selection itself is made by Prof. Albers in personal interviews.
Recommendations: Recommended Courses:
2147175 CAE-Workshop
Learning Outcomes: By working practically in experience-based learning arrangements with industrial development tasks, graduates are able to succeed in new and unknown situations when developing innovative products by using methodological and systematic approaches. They can apply and adapt strategies of development and innovation management, technical system analysis and team leadership to the situation. As a result, they are able to foster the development of innovative products in industrial development teams in prominent positions, taking into account social, economic and ethical aspects.
Remarks:

SP 21: Nuclear Energy

ID	Cat	Course	Lecturer	h	CP	Term
2189903	K	Introduction to Nuclear Energy (p. 536)	X. Cheng	2	4	W
2170460	K	Nuclear Power Plant Technology (p. 651)	T. Schulenberg, K. Litfin	2	4	S
2181745	EM	Design of highly stresses components (p. 493)	J. Aktaa	2	4	W
2130910	EM	CFD for Power Engineering (p. 516)	I. Otic	2	4	S
2130929	EM	Energy systems II: Reactor Physics (p. 552)	A. Badea	2	4	S
2130973	EM	Innovative Nuclear Systems (p. 638)	X. Cheng	2	4	S
2190490	EM	Introduction to Neutron Cross Section Theory and Nuclear Data Generation (p. 644)	R. Dagan	2	4	S
2189465	EM	Reactor Safety I: Fundamentals (p. 773)	V. Sánchez-Espinoza	2	4	S
23271	EM	Radiation Protection: Ionising Radiation (p. 808)	B. Breustedt, M. Urban	2	4	W
2189910	EM	Flows and Heat Transfer in Energy Technology (p. 811)	X. Cheng	2	4	W
2189904	EM	Ten lectures on turbulence (p. 829)	I. Otic	2	4	W
2194650	EM	Materials under high thermal or neutron loads (p. 830)	A. Möslang, J. Reiser	2	4	S
2169470	EM	Two-Phase Flow and Heat Transfer (p. 874)	T. Schulenberg, M. Wörner	2	4	W

Conditions:
Recommendations:
Learning Outcomes: Students acquire the basic and advanced knowledge of nuclear technology and are able to apply the assimilated knowledge in practice and to analyze and solve by themselves important questions in the nuclear energy field.
The courses of this module are built on three levels. With the overview lecture “Introduction into Nuclear Power”, the students acquire broad basic knowledge of nuclear energy and are able to further study in-depth courses in various disciplines, namely thermal-hydraulics, reactor physics and materials science. As a result, students will understand the important processes of nuclear technology, such as control, heat transport and material behavior in a nuclear reactor. The properties of various nuclear systems, especially nuclear power plants, are available for study on the third level of the lectures. The students will possess then the ability to compare and analyze different nuclear systems.
Remarks:

SP 22: Cognitive Technical Systems

ID	Cat	Course	Lecturer	h	CP	Term
2138340	K	Automotive Vision (eng.) (p. 573)	C. Stiller, M. Lauer	3	6	S
2106014	K	Data Analytics for Engineers (p. 522)	R. Mikut, M. Reischl, J. Stegmaier	3	5	S
2138336	K	Behaviour Generation for Vehicles (p. 848)	C. Stiller, M. Werling	2	4	S
23064	E	Analysis and Design of Multisensor Systems (p. 473)	G. Trommer, G. Trommer	2	3	S
2105016	E	Computational Intelligence (p. 521)	R. Mikut, W. Jakob, M. Reischl	2	4	W
2137309	E	Digital Control (p. 528)	M. Knoop	2	4	W
2118094	E	Information Systems in Logistics and Supply Chain Management (p. 635)	C. Kilger	2	4	S
24102	E	Information Processing in Sensor Networks (p. 637)	U. Hanebeck, Christiof Chlebek	3	4	W
2138341	E	Cogitive Automobiles - Laboratory (p. 653)	C. Stiller, M. Lauer	3	6	S
24572	E	Cognitive Systems (p. 654)	R. Dillmann, A. Waibel	4	6	S
24613	E	Localization of Mobile Agents (p. 672)	U. Hanebeck	3	4	S
2137308	E	Machine Vision (p. 673)	C. Stiller, M. Lauer	4	8	W
2105014	E (P)	Laboratory mechatronics (p. 693)	C. Stiller, M. Lorch, W. Seemann	3	4	W
2138326	E	Measurement II (p. 696)	C. Stiller	2	4	S
2137306	E (P)	Lab Computer-aided methods for measurement and control (p. 747)	C. Stiller, M. Spindler	3	4	W
2162256	E	Computational Vehicle Dynamics (p. 775)	C. Proppe	2	4	S
24152	E	Robotics I – Introduction to robotics (p. 782)	R. Dillmann, T. Asfour	2	6	W
24635	E	Robotik III - Sensors in Robotics (p. 784)	R. Dillmann, Meißner, Gonzalez, Aguirre	2	3	S

Conditions:
Recommendations:
Learning Outcomes: Students are able to

- explain fundamental components and processing steps of cognitive technical systems
- explain the interplay of individual components and the flow of information between them
- outline the major properties of cognitive functions at examples in emerging applications like vehicular technology or robotics
- determine the level of system function and safety for cognitive technical systems

Remarks:

SP 23: Power Plant Technology

ID	Cat	Course	Lecturer	h	CP	Term
2169461	K	Coal fired power plants (p. 519)	T. Schulenberg	2	4	W
2170490	K	Combined Cycle Power Plants (p. 587)	T. Schulenberg	2	4	S
2157432	K	Hydraulic Fluid Machinery (p. 628)	B. Pritz	4	8	S
2170460	K	Nuclear Power Plant Technology (p. 651)	T. Schulenberg, K. Litfin	2	4	S
2169453	K	Thermal Turbomachines I (p. 833)	H. Bauer	3	6	W
2170476	K	Thermal Turbomachines II (p. 834)	H. Bauer	3	6	S
2181745	E	Design of highly stresses components (p. 493)	J. Aktaa	2	4	W
2189903	E	Introduction to Nuclear Energy (p. 536)	X. Cheng	2	4	W
2157444	E (P)	Introduction to numerical fluid dynamics (p. 540)	B. Pritz	2	4	W
2189487	E	Energy Storage and Network Integration (p. 549)	R. Stieglitz, W. Jaeger, Jäger, Noe	2	4	W
2169483	E	Fusion Technology A (p. 585)	R. Stieglitz, Fietz, Day, Boccaccini	2	4	W
2165515	E	Fundamentals of Combustion I (p. 613)	U. Maas	2	4	W
2110037	E	Occupational Safety and Environmental Protection (in German) (p. 632)	R. von Kiparski	2	4	S
2130973	E	Innovative Nuclear Systems (p. 638)	X. Cheng	2	4	S
2170463	E	Cooling of thermally high loaded gas turbine components (p. 660)	H. Bauer, A. Schulz	2	4	S
2171487	E (P)	Laboratory Exercise in Energy Technology (p. 665)	H. Bauer, U. Maas, H. Wirbser	3	4	W/S
2153441	E	Numerical Fluid Mechanics (p. 726)	F. Magagnato	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2171488	E (P)	Workshop on computer-based flow measurement techniques (p. 750)	H. Bauer	3	4	W/S
2145182	E	Project management in Global Product Engineering Structures (p. 768)	P. Gutzmer	2	4	W
2169550	E	Reliability Engineering 1 (p. 780)	A. Konnov	2	3	S
2173585	E	Fatigue of Metallic Materials (p. 790)	K. Lang	2	4	W
2170491	E (P)	Simulator Exercises Combined Cycle Power Plants (p. 802)	T. Schulenberg	2	2	S
2158107	E	Technical Acoustics (p. 820)	M. Gabi	2	4	S
2169472	E	Thermal Solar Energy (p. 831)	R. Stieglitz	2	4	W
2189423	E	Thermal-Fluid-Dynamics (p. 836)	S. Ruck	2	4	W
2169462	E	Turbine and compressor Design (p. 841)	H. Bauer, A. Schulz	2	4	W
2170495	E	Hydrogen Technologies (p. 861)	T. Jordan	2	4	S
2157381	E	Windpower (p. 869)	N. Lewald	2	4	W
2169470	E	Two-Phase Flow and Heat Transfer (p. 874)	T. Schulenberg, M. Wörner	2	4	W

Conditions: None.
Recommendations: Recommended Course:

- 22512 Heat- and Mass transfer

Learning Outcomes: After completion of SP 23 students are able:

- to name the different types of centralized and distributed power plants,
- to explain the operational principle of well-established power plants as well as of power plants based on renewable energies.
- to predict the electric, respectively thermal efficiency of power plants,
- to assess the economics of power plants,
- to highlight the environmental impact of conventional power plants and of renewable energies,
- to assess the availability, operational safety and flexibility of different types of power plants,

- to develop advanced power plants based on thermodynamic, fluid mechanical and other basics.

Remarks:

SP 24: Energy Converting Engines

ID	Cat	Course	Lecturer	h	CP	Term
2157432	K	Hydraulic Fluid Machinery (p. 628)	B. Pritz	4	8	S
2169453	K	Thermal Turbomachines I (p. 833)	H. Bauer	3	6	W
2133113	K	Combustion Engines I (p. 846)	H. Kubach, T. Koch	3	4	W
22527	E	Design of a jet engine combustion chamber (p. 492)	N. Zarzalis	2	6	W
2133108	E	Fuels and Lubricants for Combustion Engines (p. 501)	B. Kehrwald, H. Kubach	2	4	W
2157444	E (P)	Introduction to numerical fluid dynamics (p. 540)	B. Pritz	2	4	W
2154446	E	Experimental Fluid Mechanics (p. 559)	J. Kriegseis	2	4	S
2114093	E	Fluid Technology (p. 584)	M. Geimer, M. Scherer, L. Brink-schulte	4	5	W
2154200	E	Gasdynamics (p. 588)	F. Magagnato	2	4	W
2134138	E	Fundamentals of catalytic exhaust gas aftertreatment (p. 604)	E. Lox, H. Ku-bach, O. Deutsch-mann, J. Grun-waldt	2	4	S
2165515	E	Fundamentals of Combustion I (p. 613)	U. Maas	2	4	W
2166538	E	Fundamentals of Combustion II (p. 614)	U. Maas	2	4	S
2153441	E	Numerical Fluid Mechanics (p. 726)	F. Magagnato	2	4	W
2113072	E	Development of Oil-Hydraulic Power-train Systems (p. 766)	G. Geerling, S. Becker	2	4	W
2169550	E	Reliability Engineering 1 (p. 780)	A. Konnov	2	3	S
2158107	E	Technical Acoustics (p. 820)	M. Gabi	2	4	S
2170476	E	Thermal Turbomachines II (p. 834)	H. Bauer	3	6	S
2170478	E	Turbo Jet Engines (p. 842)	H. Bauer, A. Schulz	2	4	S
2169462	EM	Turbine and compressor Design (p. 841)	H. Bauer, A. Schulz	2	4	W
2157381	E	Windpower (p. 869)	N. Lewald	2	4	W
2153438	E	Vortex Dynamics (p. 870)	J. Kriegseis	2	4	W
2134153	E	Boosting of Combustion Engines (p. 486)	J. Kech	2	4	S

Conditions:
Recommendations: Recommended compulsory optional subject
2165512 Heat and mass transfer
Learning Outcomes: Die Studierenden erwerben in den grundlagenorientierten Kernfächern des Schwerpunktes breite und fundierte Kenntnisse der wissenschaftlichen Theorien, Prinzipien und Methoden der Kraft- und Arbeitsmaschinen, um diese entwerfen, einsetzen und bewerten zu können.
Darauf aufbauend vertiefen die Studierenden in den Ergänzungsfächern ausgewählte Anwendungsfelder, sodass sie im Anschluss in der Lage sind, Probleme aus diesem Anwendungsfeld selbstständig zu analysieren, zu bewerten und hierauf aufbauend Lösungsansätze zu entwickeln.
Die Studierenden können nach Abschluss des Schwerpunkts insbesondere

- Funktion und Einsatz von Kraft- und Arbeitsmaschinen benennen,
- den Stand der Technik und daraus resultierende Anwendungsfelder der Kraft- und Arbeitsmaschinen beschreiben und am Beispiel anzuwenden,
- grundlegende Theorien, Methoden und Eigenschaften für die verschiedenen Anwendungsfelder der Kraft- und Arbeitsmaschinen benennen und diese einsetzen und bewerten.

Remarks:

SP 25: Lightweight Construction

ID	Cat	Course	Lecturer	h	CP	Term
2113102	KP	Vehicle Lightweight design – Strategies, Concepts, Materials (p. 570)	F. Henning	2	4	W
2114053	KP	Composite Manufacturing – Polymers, Fibers, Semi-Finished Products, Manufacturing Technologies (p. 574)	F. Henning	2	4	S
2150904	E	Automated Manufacturing Systems (p. 496)	J. Fleischer	6	8	S
2147175	E	CAE-Workshop (p. 514)	A. Albers, Assistenten	3	4	W/S
2162282	E	Introduction to the Finite Element Method (p. 535)	T. Böhlke	4	5	S
2117500	E	Energy efficient intralogistic systems (p. 547)	M. Braun, F. Schönung	2	4	W
2174575	E	Foundry Technology (p. 594)	C. Wilhelm	2	4	S
2161252	E	Advanced Methods in Strength of Materials (p. 623)	T. Böhlke	4	4	W
2174571	E	Design with Plastics (p. 656)	M. Liedel	2	4	S
2146190	EM	Lightweight Engineering Design (p. 657)	A. Albers, N. Burkardt	2	4	S
2182642	E	Laser in automotive engineering (p. 663)	J. Schneider	2	4	S
2149669	E	Materials and Processes for Body Lightweight Construction in the Automotive Industry (p. 681)	D. Steegmüller, S. Kienzle	2	4	W
2173590	E	Polymer Engineering I (p. 737)	P. Elsner	2	4	W
2114107	E	Simulation of the process chain of continuously fiber reinforced composite structures (p. 797)	L. Kärger	2	4	S
2113106	E	Structural Analysis of Composite Laminates (p. 814)	L. Kärger	2	4	W
2181715	E	Failure of Structural Materials: Fatigue and Creep (p. 849)	P. Gruber, P. Gumbsch, O. Kraft	2	4	W
2181711	E	Failure of structural materials: deformation and fracture (p. 851)	P. Gumbsch, D. Weygand, O. Kraft	3	4	W
2174574	EM	Materials for Lightweight Construction (p. 864)	K. Weidenmann	2	4	S
2150550	E (P)	Laboratory Production Metrology (p. 752)	B. Häfner	3	4	S
2161983	E	Mechanics of laminated composites (p. 690)	E. Schnack	2	4	W
2162255	E	Designing with composites (p. 531)	E. Schnack	2	4	S

Conditions:
Recommendations: Empfohlene Wahlpflichtfächer:

- 2174576 Systematische Werkstoffauswahl

Learning Outcomes: Leichtbau ist die Umsetzung eine Entwicklungsstrategie, die darauf ausgerichtet ist, die geforderte Funktion unter vorgegebenen Randbedingungen durch ein System minimaler Masse über die Produktlebenszeit zu realisieren.

Leichtbaubestrebungen lassen sich daher immer als Optimierungsproblem ausdrücken, dass durch geeignete Maßnahmen möglichst effizient gelöst werden muss. Bezogen auf die Fahrzeugindustrie bedeutet das, die Fahrzeuggesamtmasse zu reduzieren ohne dabei wichtige Eigenschaften wie die Karosseriesteifigkeiten und Crasheigenschaften negativ zu beeinflussen.

Um das Optimierungsproblem Leichtbau technisch wie wirtschaftlich möglichst effizient zu lösen, bedarf es einem interdisziplinären Ansatz. Das heißt, es bedarf spezifischem Know-how in vielen Bereichen der Werkstoff- und Ingenieurwissenschaften, sowie bereichsübergreifendem Denken.

Die Nutzung des maximalen Leichtbaupotentials geht daher einher mit der gezielten Werkstoffentwicklung, der Entwicklung und Anpassung geeigneter Herstellungs- und Nachbearbeitungsverfahren, sowie der Entwicklung von Berechnungstools und Auslegungsmethoden für innovative Leichtbaukonstruktionen.

Die Studierenden erwerben Fähigkeiten die Grundlagen des Leichtbaus zu benennen und auf Problemstellungen in verschiedenen Bereichen des Maschinenbaus, insbesondere der Werkstoffe, der Methoden und der Produktion anzuwenden.

Als elementarer Bestandteil des Moduls können die Studierenden die für den Leichtbau relevanten Werkstoffe erläutern und anwenden. Die Studierenden sind in der Lage, die für den Leichtbau wichtigen Werkstoffe zu beschreiben und zu vergleichen sowie die entsprechenden Methoden zur Konstruktion, Auslegung und Dimensionierung unter der Berücksichtigung entsprechender Verarbeitungstechnologien anzuwenden.

Anhand von Vereinfachungen, die auch in der Praxis Anwendung finden, werden die Studierenden in die Lage versetzt, geeignete Werkstoffe auszuwählen, diese mit geeigneten Methoden zu beschreiben und Produkte unter Berücksichtigung des Herstellprozesses zu entwickeln. Hierbei lernen die Studierenden Prozesse zu analysieren und auf Ihre Effizienz hin zu beurteilen.

Remarks:

SP 26: Materials Science and Engineering

ID	Cat	Course	Lecturer	h	CP	Term
2173553	K	Materials Science and Engineering III (p. 865)	M. Heilmaier, K. Lang	5	8	W
2181740	E	Atomistic simulations and molecular dynamics (p. 483)	C. Brandl, P. Gumbsch	2	4	S
2194643	E	Constitution and Properties of Wear resistant materials (p. 484)	S. Ulrich	2	4	S
2177601	EM	Constitution and Properties of Protective Coatings (p. 485)	S. Ulrich	2	4	W
2181708	E/P	Biomechanics: design in nature and inspired by nature (p. 505)	C. Mattheck	3	4	W
2181731	EM	Fatigue of Welded Components and Structures (p. 556)	M. Farajian, P. Gumbsch,	2	4	W
2175590	E (P)	Metallographic Lab Class (p. 560)	U. Hauf	3	4	W/S
2174575	E	Foundry Technology (p. 594)	C. Wilhelm	2	4	S
2193010	E	Basic principles of powder metallurgical and ceramic processing (p. 603)	G. Schell, R. Oberacker	2	4	W
2125757	E	Introduction to Ceramics (p. 648)	M. Hoffmann	4	6	W
2174571	E	Design with Plastics (p. 656)	M. Liedel	2	4	S
2182642	E	Laser in automotive engineering (p. 663)	J. Schneider	2	4	S
2162280	EM	Mathematical Methods in Structural Mechanics (p. 687)	T. Böhlke	3	5	S
2173580	E	Mechanics and Strength of Polymers (p. 691)	B. Graf von Bernstorff	2	4	W
2183702	E	Modelling of Microstructures (p. 702)	A. August, B. Nestler, D. Weygand	3	5	W
2162344	EM	Nonlinear Continuum Mechanics (p. 720)	T. Böhlke	2	5	S
2181750	EM	Multi-scale Plasticity (p. 734)	K. Schulz, C. Greiner	2	4	W
2173590	E	Polymer Engineering I (p. 737)	P. Elsner	2	4	W
2183640	E (P)	Laboratory “Laser Materials Processing” (p. 746)	J. Schneider, W. Pfleging	3	4	W/S
2126749	EM	Advanced powder metals (p. 770)	R. Oberacker	2	4	S
2182572	E	Failure Analysis (p. 786)	C. Greiner, J. Schneider	2	4	W
2173571	E	Welding Technology (p. 788)	M. Farajian	2	4	W
2173585	E	Fatigue of Metallic Materials (p. 790)	K. Lang	2	4	W
2126775	EM	Structural Ceramics (p. 815)	M. Hoffmann	2	4	S
2174579	E	Technology of steel components (p. 828)	V. Schulze	2	4	S
2181715	E	Failure of Structural Materials: Fatigue and Creep (p. 849)	P. Gruber, P. Gumbsch, O. Kraft	2	4	W
2181711	E	Failure of structural materials: deformation and fracture (p. 851)	P. Gumbsch, D. Weygand, O. Kraft	3	4	W
2174586	E	Materials Characterization (p. 863)	J. Gibmeier	3	7	W
2174574	E	Materials for Lightweight Construction (p. 864)	K. Weidenmann	2	4	S
2182740	EM	Materials modelling: dislocation based plasticity (p. 866)	D. Weygand	2	4	S
2161983	EM	Mechanics of laminated composites (p. 690)	E. Schnack	2	4	W
2193003	EM	Solid State Reactions and Kinetics of Phase Transformations (with exercises) (p. 579)	P. Franke	2	4	W

ID	Cat	Course	Lecturer	h	CP	Term
2193002	EM	Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises) (p. 835)	H. Seifert	2	5	W

Conditions: None
Recommendations:
Learning Outcomes: As part of a major field a specific subdomain of mechanical engineering is made accessible in breadth and depth. Students gain comprehensive knowledge in the core subjects and detailed knowledge in the supplementary subjects of the selected subdomain. They are able to generate new (scientific) solutions within this subdomain.
The specific learning outcomes are defined by the respective coordinator of the major field.
Remarks: The module Materials Science and Engineering consists of 12 credit points in the bachelor´s program and 16 credit points each in the master´s program, respectively. Within that module, the students have to take lectures from a core area (8 credit points) and can select from a broad variation of courses within the supplementary area. For the bachelor´s program, a reduced catalogue exists (see Studienplan).

SP 27: Modeling and Simulation in Energy- and Fluid Engineering

ID	Cat	Course	Lecturer	h	CP	Term
2167523	K	Modeling of Thermodynamical Processes (p. 708)	R. Schießl, U. Maas	3	6	W/S
2169458	K	Numerical simulation of reacting two phase flows (p. 724)	R. Koch	2	4	W
2153441	K	Numerical Fluid Mechanics (p. 726)	F. Magagnato	2	4	W
2130910	E	CFD for Power Engineering (p. 516)	I. Otic	2	4	S
2154200	E	Gasdynamics (p. 588)	F. Magagnato	2	4	W
2165525	E	Mathematical models and methods in combustion theory (p. 688)	V. Bykov, U. Maas	2	4	W
2134134	E	Analysis tools for combustion diagnostics (p. 697)	J. Pfeil	2	4	S
2130934	E	Numerical Modeling of Multiphase Flows (p. 723)	M. Wörner	2	4	S
2153449	E	Numerical Simulation of Turbulent Flows (p. 725)	G. Grötzbach	3	4	W
2166543	E	Reduction methods for the modeling and the simulation of combustion processes (p. 779)	V. Bykov, U. Maas	2	4	S
2153406	E	Flows with chemical reactions (p. 810)	A. Class	2	4	W
2189910	E	Flows and Heat Transfer in Energy Technology (p. 811)	X. Cheng	2	4	W
2189904	E	Ten lectures on turbulence (p. 829)	I. Otic	2	4	W
2189423	E	Thermal-Fluid-Dynamics (p. 836)	S. Ruck	2	4	W
2123375	E	Virtual Reality Laboratory (p. 858)	J. Ovtcharova	3	4	W/S

Conditions: None.
Recommendations: Recommended Lecture:

- 2154432 Mathematische Methoden der Strömungslehre

Learning Outcomes: After completing SP 27 students can:

- formulate the governing equations for specific systems in energy and fluid mechanics.
- explain the different numerical schemes applied to solve the system of equations.
- use frequently applied simulation tools in a more efficient and successful way.

Remarks:

SP 28: Lifecycle Engineering

ID	Cat	Course	Lecturer	h	CP	Term
2121352	KP	Virtual Engineering I (p. 855)	J. Ovtcharova	4	4	W
2122378	KP	Virtual Engineering II (p. 856)	J. Ovtcharova	3	4	S
2123357	EM (P)	CAD-NX training course (p. 513)	J. Ovtcharova	2	2	W/S
2147175	E	CAE-Workshop (p. 514)	A. Albers, Assistenten	3	4	W/S
2123380	E	CATIA advanced (p. 515)	J. Ovtcharova	3	4	W/S
2109021	E	Human-oriented Productivity Management: Personnel Management (p. 624)	P. Stock	2	4	W
2109042	E	Introduction to Industrial Production Economics (p. 631)	S. Dürrschnabel	2	4	W
2122014	E	Information Engineering (p. 634)	J. Ovtcharova	2	3	S
2123352	E	IoT platform for engineering (p. 645)	J. Ovtcharova, T. Maier	3	4	W/S
2117059	E	Mathematical models and methods for Production Systems (p. 689)	K. Furmans, M. Rimmele	4	6	W
2122376	E	PLM for Product Development in Mechatronics (p. 735)	M. Eigner	2	4	S
2121350	E	Product Lifecycle Management (p. 755)	J. Ovtcharova, T. Maier	3	4	W
2110046	E	Productivity Management in Production Systems (p. 762)	S. Stowasser	2	4	S
2149680	E	Project Mikro Manufacturing: Design and Manufacturing of Micro Systems (p. 765)	V. Schulze, B. Matuschka, A. Kacaras	3	6	W
2117061	E	Safety Engineering (p. 795)	H. Kany	2	4	W
2117062	E	Supply chain management (p. 817)	K. Alicke	4	6	W
2146192	E	Sustainable Product Engineering (p. 818)	K. Ziegahn	2	4	S
2123350	E	Virtual Engineering Lab (p. 857)	J. Ovtcharova	3	4	W/S
2123351	E	Virtual training factory 4.X (p. 859)	J. Ovtcharova	3	4	W/S
2122310	E	Digitalization of Products, Services & Production (p. 529)	B. Pätzold	2	4	S

Conditions:
Recommendations:
Learning Outcomes: Student gain a basic understanding of holistic development, validation and production of products, components and systems.
Students are able to appreciate the product and process complexity of today's products and manufacturing facilities. They know exemplary IT-Systems to support the complexity.
Students can describe the necessary information management for the product emergence process.
Students know the fundamental terms or virtual reality and are able to use a CAVE as tool to promote technical or management decisions.
Remarks:

SP 29: Logistics and Material Flow Theory

ID	Cat	Course	Lecturer	h	CP	Term
2117051	KP	Material flow in logistic systems (p. 679)	K. Furmans	4	6	W
2118078	K	Logistics - organisation, design and control of logistic systems (p. 669)	K. Furmans	4	6	S
2117059	K	Mathematical models and methods for Production Systems (p. 689)	K. Furmans, M. Rimmele	4	6	W
2137309	E	Digital Control (p. 528)	M. Knoop	2	4	W
2117096	E	Elements of Technical Logistics (p. 543)	M. Mittwollen, G. Fischer	3	4	W
2117097	E	Elements of Technical Logistics - Project (p. 544)	M. Mittwollen, G. Fischer	4	2	W
2149610	E	Global Production and Logistics - Part 1: Global Production (p. 595)	G. Lanza	2	4	W
2149600	E	Global Production and Logistics - Part 2: Global Logistics (p. 597)	K. Furmans, O. Zimmermann	2	4	S
2117095	E	Basics of Technical Logistics (p. 612)	M. Mittwollen, J. Oellerich	4	6	W
2118094	E	Information Systems in Logistics and Supply Chain Management (p. 635)	C. Kilger	2	4	S
2118097	E	Warehousing and distribution systems (p. 661)	K. Furmans	2	4	S
2118085	E	Automotive Logistics (p. 670)	K. Furmans	2	4	S
2117056	E	Airport logistics (p. 671)	A. Richter	2	4	W
2500005	E	Production and Logistics Controlling (p. 758)	H. Wlcek	2	3	W
2110678	E (P)	Production Techniques Laboratory (p. 760)	K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL	3	4	S
2110046	E	Productivity Management in Production Systems (p. 762)	S. Stowasser	2	4	S
2117062	E	Supply chain management (p. 817)	K. Alicke	4	6	W

Conditions: none
Recommendations: Recommended compulsory optional subjects:

- Basics of statistic and probability theory
- Simulation of production systems and processes
- Stochastics in Mecanical Engineering
- Modelling and Simulation
- Technical Logistics I

Learning Outcomes: Students

- acquire comprehensive and well-founded knowledge on the main topics of logistics, an overview of different logistic questions in practice and knows the functionality of material handling systems,
- are able to illustrate logistic systems with adequate accuracy by using simple models,
- are able to realize coherences within logistic systems,
- are able to evaluate logistic systems by using the learnt methods,
- are able to analyze and explain the phenomena of industrial material and value streams
- are able to plan logistic systems and evaluate their performance,
- can use approaches of Supply Chain Management within the operational practice,
- identify, analyse and evaluate risks within logistic systems.

Remarks: none

SP 30: Applied Mechanics

ID	Cat	Course	Lecturer	h	CP	Term
2161250	K	Computational Mechanics I (p. 777)	T. Böhlke, T. Langhoff	4	6	W
2162296	K	Computational Mechanics II (p. 778)	T. Böhlke, T. Langhoff	4	6	S
2182732	E	Introduction to Theory of Materials (p. 537)	M. Kamlah	2	4	S
2162247	E	Introduction to Nonlinear Vibrations (p. 541)	A. Fidlin	4	7	W
2181720	E	Foundations of nonlinear continuum mechanics (p. 610)	M. Kamlah	2	4	W
2162280	E	Mathematical Methods in Structural Mechanics (p. 687)	T. Böhlke	3	5	S
2183702	E	Modelling of Microstructures (p. 702)	A. August, B. Nestler, D. Weygand	3	5	W
2162344	E	Nonlinear Continuum Mechanics (p. 720)	T. Böhlke	2	5	S
2161123	E	Computational Homogenization on Digital Image Data (p. 520)	M. Schneider	2	6	W
0187400	E	Numerical Mathematics (p. 722)	C. Wieners, D. Weiß, Neuß, Rieder	3	6	S
2161501	E	Process Simulation in Forming Operations (p. 769)	D. Helm	2	4	W
2162246	E	Computational Dynamics (p. 774)	C. Proppe	2	4	S
2162256	E	Computational Vehicle Dynamics (p. 775)	C. Proppe	2	4	S
2114107	E	Simulation of the process chain of continuously fiber reinforced composite structures (p. 797)	L. Kärger	2	4	S
2163113	E	Theory of Stability (p. 805)	A. Fidlin	4	6	S
2113106	E	Structural Analysis of Composite Laminates (p. 814)	L. Kärger	2	4	W
2161212	E	Vibration Theory (p. 825)	A. Fidlin	3	5	W
2182740	E	Materials modelling: dislocation based plasticy (p. 866)	D. Weygand	2	4	S
2181738	E	Scientific computing for Engineers (p. 871)	D. Weygand, P. Gumbsch	2	4	W

Conditions:
Recommendations: Recommended compulsory elective subjects:

- 2161206 Mathematical Methods in Dynamics
- 2161254 Mathematical Methods in Strength of Materials
- 2162280 Mathematical Methods in Structural Mechanics
- 2154432 Mathematical Methods in Fluid Dynamics

Learning Outcomes: After having finished this major field the students can

- list important mathematical concepts that are applied in mechanics
- analyze, evaluate and assess models of mechanics according to their mathematical structure
- apply mathematical algorithms for solving special problems in mechanics
- select a mathematical description of a given problem in mechanics

Remarks:

SP 31: Mechatronics

ID	Cat	Course	Lecturer	h	CP	Term
2138340	K	Automotive Vision (eng.) (p. 573)	C. Stiller, M. Lauer	3	6	S
2105016	K	Computational Intelligence (p. 521)	R. Mikut, W. Jakob, M. Reischl	2	4	W
2106014	K	Data Analytics for Engineers (p. 522)	R. Mikut, M. Reischl, J. Stegmaier	3	5	S
2105011	K	Introduction into Mechatronics (p. 538)	M. Reischl, M. Lorch	3	6	W
2162235	K	Introduction into the multi-body dynamics (p. 539)	W. Seemann	3	5	S
2105024	K	Modern Control Concepts I (p. 709)	J. Matthes, L. Gröll	2	4	S
2105018	E	Simulation of Optical Systems (p. 800)	I. Sieber	2	4	W
2138336	K	Behaviour Generation for Vehicles (p. 848)	C. Stiller, M. Werling	2	4	S
2150904	E	Automated Manufacturing Systems (p. 496)	J. Fleischer	6	8	S
2106005	E	Automation Systems (p. 498)	M. Kaufmann	2	4	S
2114092	E	BUS-Controls (p. 511)	M. Geimer	2	4	S
2147175	E	CAE-Workshop (p. 514)	A. Albers, Assistenten	3	4	W/S
2137309	E	Digital Control (p. 528)	M. Knoop	2	4	W
23321	E	Hybrid and Electric Vehicles (p. 626)	M. Doppelbauer, M. Schiefer	3	4	W
2118183	E	IT-Fundamentals of Logistics (p. 646)	F. Thomas	2	4	S
2161224	E	Machine Dynamics (p. 677)	C. Proppe	3	5	S
2162220	E	Machine Dynamics II (p. 678)	C. Proppe	2	4	W
2181710	E	Mechanics in Microtechnology (p. 692)	P. Gruber, C. Greiner	2	4	W
2105014	E (P)	Laboratory mechatronics (p. 693)	C. Stiller, M. Lorch, W. Seemann	3	4	W
24659	E	Human-Machine-Interaction (p. 694)	M. Beigl	2	3	S
2138326	E	Measurement II (p. 696)	C. Stiller	2	4	S
2142897	E	Microenergy Technologies (p. 698)	M. Kohl	2	4	S
2141865	E	Novel actuators and sensors (p. 717)	M. Kohl, M. Sommer	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2145182	E	Project management in Global Product Engineering Structures (p. 768)	P. Gutzmer	2	4	W
24152	E	Robotics I – Introduction to robotics (p. 782)	R. Dillmann, T. Asfour	2	6	W
23109	E	Signals and Systems (p. 796)	F. Puente, F. Puente León	2	6	W
2146192	E	Sustainable Product Engineering (p. 818)	K. Ziegahn	2	4	S
2106033	E	System Integration in Micro- and Nanotechnology (p. 819)	U. Gengenbach	2	4	S
2123375	E	Virtual Reality Laboratory (p. 858)	J. Ovtcharova	3	4	W/S
2150550	E (P)	Laboratory Production Metrology (p. 752)	B. Häfner	3	4	S
2105032	E	Micro- and nanosystem integration for medical, fluidic and optical applications (p. 700)	L. Koker, U. Gengenbach, I. Sieber	2	4	W
2162240	EM	Mathematical Foundation for Computational Mechanics (p. 682)	E. Schnack	2	4	S

Conditions:
Recommendations:

Learning Outcomes: The topic mechatronics offers a broad, multidisciplinary body of knowledge. The graduates are qualified to solve essential mechatronic questions. In particular the following disciplines are covered by the major mechatronics:
§ Mechanics and fluidics
§ Electronics
§ Information processing
§ Automation.
Students of the topic mechatronics know the future-oriented procedures. They are able to individually and creatively solve interdisciplinary questions and learn to effectively combine tools from the individual disciplines.
Remarks:

SP 32: Medical Technology

ID	Cat	Course	Lecturer	h	CP	Term
2105011	KP	Introduction into Mechatronics (p. 538)	M. Reischl, M. Lorch	3	6	W
2141864	K	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I (p. 506)	A. Guber	2	4	W
2142883	K	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II (p. 507)	A. Guber	2	4	S
2142879	K	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III (p. 508)	A. Guber	2	4	S
2105016	K	Computational Intelligence (p. 521)	R. Mikut, W. Jakob, M. Reischl	2	4	W
2106014	K	Data Analytics for Engineers (p. 522)	R. Mikut, M. Reischl, J. Stegmaier	3	5	S
2105992	K	Principles of Medicine for Engineers (p. 605)	C. Pylatiuk	2	4	W
2141866	E	Actuators and sensors in nanotechnology (p. 470)	M. Kohl	2	4	W
23261	E	Medical Imaging Techniques I (p. 502)	O. Dössel	2	3	W
23262	E	Medical Imaging Techniques II (p. 503)	O. Dössel, O. Dössel	2	3	S
23264	E	Bioelectric Signals (p. 504)	G. Seemann, G. Seemann	2	3	S
2142140	E	Bionics for Engineers and Natural Scientists (p. 509)	H. Hölscher	2	4	S
2106008	E	Organ support systems (p. 557)	C. Pylatiuk	2	4	S
24139	E	Human brain and central nervous system: anatomy, information transfer, signal processing, neurophysiology and therapy (p. 591)	U. Spetzger	2	3	W
24678	E	Human brain and central nervous system: anatomy, information transfer, signal processing, neurophysiology and therapy (p. 592)	U. Spetzger	2	3	S
2146190	E	Lightweight Engineering Design (p. 657)	A. Albers, N. Burkardt	2	4	S
2181710	E	Mechanics in Microtechnology (p. 692)	P. Gruber, C. Greiner	2	4	W
23105	E	Measurement Technology (p. 695)	F. Puente	3	4	W
23289	E	Nuklear Medicine and Nuklear Medicine Measurement Technics I (p. 721)	F. Maul, H. Doerfel	1	2	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2143875	E	Introduction to Microsystem Technology - Practical Course (p. 753)	A. Last	2	4	W/S
2149680	E	Project Mikro Manufacturing: Design and Manufacturing of Micro Systems (p. 765)	V. Schulze, B. Matuschka, A. Kacaras	3	6	W
2145182	E	Project management in Global Product Engineering Structures (p. 768)	P. Gutzmer	2	4	W
24152	E	Robotics I – Introduction to robotics (p. 782)	R. Dillmann, T. Asfour	2	6	W
24644	E	Robotik II: Humanoide Robotic (p. 783)	R. Dillmann, T. Asfour	2	3	S
24635	E	Robotik III - Sensors in Robotics (p. 784)	R. Dillmann, Meißner, Gonzalez, Aguirre	2	3	S
24681	E	Medical Robotics (p. 785)	J. Raczkowsky, Raczkowsky	2	3	S
2105018	E	Simulation of Optical Systems (p. 800)	I. Sieber	2	4	W

ID	Cat	Course	Lecturer	h	CP	Term
2106033	E	System Integration in Micro- and Nano-technology (p. 819)	U. Gengenbach	2	4	S
2105032	E	Micro- and nanosystem integration for medical, fluidic and optical applications (p. 700)	L. Koker, U. Gengenbach, I. Sieber	2	4	W

Conditions:
Recommendations:
Learning Outcomes: The Medical Engineering qualifies students to solve challenges in the field of complex medical and bio-medical systems supporting human-centred diagnostics and therapy. Based on the specific requirements for medical products the following topics are taught within the major Medical Engineering:

- Broad basis of relevant medical and biological knowledge
- Measuring technology and signal processing
- Development and Manufacturing of medical products

Graduates of this major know all relevant methods to design modern medical devices and have the ability to efficiently and creatively develop solutions for leading edge medical applications.
Remarks:

SP 33: Microsystem Technology

ID	Cat	Course	Lecturer	h	CP	Term
2141861	KP	Introduction to Microsystem Technology I (p. 606)	J. Korvink, V. Badilita, M. Jouda	2	4	W
2142874	K	Introduction to Microsystem Technology II (p. 608)	J. Korvink, M. Jouda	2	4	S
2141866	E	Actuators and sensors in nanotechnology (p. 470)	M. Kohl	2	4	W
2143873	E	Actual topics of BioMEMS (p. 471)	A. Guber	2	4	W/S
2143892	E	Selected Topics on Optics and Microoptics for Mechanical Engineers (p. 489)	T. Mappes	2	4	S
2141864	E	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I (p. 506)	A. Guber	2	4	W
2142883	E	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II (p. 507)	A. Guber	2	4	S
2142879	E	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III (p. 508)	A. Guber	2	4	S
2142140	E	Bionics for Engineers and Natural Scientists (p. 509)	H. Hölscher	2	4	S
2142551	E (P)	NMR micro probe hardware conception and construction (p. 525)	J. Korvink, M. Jouda	2	4	S
2143882	E	Fabrication Processes in Microsystem Technology (p. 576)	K. Bade	2	4	W/S
2141007	E	Fundamentals of X-ray Optics I (p. 611)	A. Last	2	4	W
2181710	E	Mechanics in Microtechnology (p. 692)	P. Gruber, C. Greiner	2	4	W
2142897	E	Microenergy Technologies (p. 698)	M. Kohl	2	4	S
2141501	E	Micro Magnetic Resonannce (p. 699)	J. Korvink, N. MacKinnon	2	4	W
2142881	E	Microactuators (p. 701)	M. Kohl	2	4	S
2142875	E	Microsystem Simulation (p. 703)	J. Korvink	3	6	S
2141503	E	Microsystem product design for young entrepreneurs (p. 704)	J. Korvink, D. Mager	4	6	W
2142880	E	Miniaturized Heat Exchangers (p. 705)	J. Brandner	2	4	S
2142861	E	Nanotechnology for Engineers and Natural Scientists (p. 714)	H. Hölscher, M. Dienwiebel, S. Walheim	2	4	S
2141865	E	Novel actuators and sensors (p. 717)	M. Kohl, M. Sommer	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2141853	E	Polymers in MEMS A: Chemistry, Synthesis and Applications (p. 739)	B. Rapp	2	4	W
2141854	E	Polymers in MEMS B: Physics, Microstructuring and Applications (p. 741)	M. Worgull	2	4	W
2142855	E	(p. 743)	M. Worgull, B. Rapp	2	4	S
2142856	E (P)	(p. 745)	M. Worgull, B. Rapp	2	3	S
2143875	E	Introduction to Microsystem Technology - Practical Course (p. 753)	A. Last	2	4	W/S
2143876	E	Nanotechnology with Clusterbeams (p. 715)	J. Gspann	2	4	W

Conditions:
Recommendations:
Learning Outcomes: In this key area, attendees gain competence in the design, construction, production, and application of **micro and nano systems**. Microsystems comprise the **smallest human-made** components. These include sensors, actuators, and system components working together for form a more powerful whole. Micro and nano systems are the basis for numerous

smart products, such as **smart dust**, smart buildings, the **internet of things**, smart consumer-ware, smart mobility, and smart production via **industry 4.0** concepts.
The **increasing control** over morphology at the nano and microscale is enabling the bottom up construction of **passive and active materials** with ideal and unheard-of properties, embedded in the devices that can make use of these, and are therefore **revolutionising** the world of products and scientific instrumentation.
Remarks: If you have any questions concerning the module, or in planning a suitable packages of courses, please contact **Prof. Dr. Jan G. Korvink** (*jan.korvink@kit.edu*).

SP 34: Mobile Machines

ID	Cat	Course	Lecturer	h	CP	Term
2114073	KP	Mobile Machines (p. 706)	M. Geimer	4	8	S
2113077	E	Drive Train of Mobile Machines (p. 475)	M. Geimer, M. Scherer, D. Engelmann	3	4	W
2113079	E	Design and Development of Mobile Machines (p. 494)	M. Geimer, J. Siebert	2	4	W
2138340	E	Automotive Vision (eng.) (p. 573)	C. Stiller, M. Lauer	3	6	S
2114092	E	BUS-Controls (p. 511)	M. Geimer	2	4	S
2117500	E	Energy efficient intralogistic systems (p. 547)	M. Braun, F. Schönung	2	4	W
2114093	E	Fluid Technology (p. 584)	M. Geimer, M. Scherer, L. Brinkschulte	4	5	W
2113812	E	Fundamentals in the Development of Commercial Vehicles I (p. 618)	J. Zürn	1	2	W
2114844	E	Fundamentals in the Development of Commercial Vehicles II (p. 619)	J. Zürn	1	2	S
2113072	E	Development of Oil-Hydraulic Powertrain Systems (p. 766)	G. Geerling, S. Becker	2	4	W
2145182	E	Project management in Global Product Engineering Structures (p. 768)	P. Gutzmer	2	4	W
2114095	E	Simulation of Coupled Systems (p. 798)	M. Geimer	4	4	S
2113080	E	Tractors (p. 838)	M. Kremmer, M. Scherer	2	4	W
2133113	E	Combustion Engines I (p. 846)	H. Kubach, T. Koch	3	4	W
2138336	E	Behaviour Generation for Vehicles (p. 848)	C. Stiller, M. Werling	2	4	S
2110050	E	Vehicle Ergonomics (p. 565)	T. Heine	2	4	S

Conditions:
Recommendations: Knowledge of Fluid Power Systems is helpful, otherwise it is recommended to take the course *Fluid Technology* [2114093].
Learning Outcomes: The student

- knows and understands the basic structure of the machines,
- masters the basic skills to develop the selected machines

Remarks:

SP 36: Polymer Engineering

ID	Cat	Course	Lecturer	h	CP	Term
2173590	K	Polymer Engineering I (p. 737)	P. Elsner	2	4	W
2174596	K	Polymer Engineering II (p. 738)	P. Elsner	2	4	S
2113102	E	Vehicle Lightweight design – Strategies, Concepts, Materials (p. 570)	F. Henning	2	4	W
2114053	E	Composite Manufacturing – Polymers, Fibers, Semi-Finished Products, Manufacturing Technologies (p. 574)	F. Henning	2	4	S
2174571	E	Design with Plastics (p. 656)	M. Liedel	2	4	S
2173580	E	Mechanics and Strength of Polymers (p. 691)	B. Graf von Bernstorff	2	4	W

Conditions:
Recommendations: suggested optional compulsory subject:

- 2174576 Systematic Materials Selection

Learning Outcomes: The students...

- are able to choose polymers for abblications in mechanical engineering in target-oriented way and are able to justify their selection.
- are able to describe and compare production processes for polymers and PMCs exemplarily.
- are able to describe the mechanical behaviour of polymers and PMC based on scientific theories, principles and methods.
- are able to solve tasks in the field of polymer engineering and proceed adequate to the situation.
- are able to integrate intra-modular knowledge at the solution of given problems.
- have the ability to develop polymer parts in a constructive way under consideration of technical and economic conditions.

Remarks: Emphasis module in the master´s program only.

SP 39: Production Technology

ID	Cat	Course	Lecturer	h	CP	Term
2150904	K	Automated Manufacturing Systems (p. 496)	J. Fleischer	6	8	S
2149657	K	Manufacturing Technology (p. 577)	V. Schulze, F. Zanger	6	8	W
2149610	K	Global Production and Logistics - Part 1: Global Production (p. 595)	G. Lanza	2	4	W
2149600	K	Global Production and Logistics - Part 2: Global Logistics (p. 597)	K. Furmans, O. Zimmermann	2	4	S
2150660	K	Integrated Production Planning in the Age of Industry 4.0 (p. 643)	G. Lanza	6	8	S
2149902	K	Machine Tools and Industrial Handling (p. 867)	J. Fleischer	6	8	W
2117096	E	Elements of Technical Logistics (p. 543)	M. Mittwollen, G. Fischer	3	4	W
2117097	E	Elements of Technical Logistics - Project (p. 544)	M. Mittwollen, G. Fischer	4	2	W
2117500	E	Energy efficient intralogistic systems (p. 547)	M. Braun, F. Schönung	2	4	W
2149903	E	Design Project Machine Tools and Industrial Handling (p. 555)	J. Fleischer	2	4	W
2173560	E (P)	Welding Lab Course, in groupes (p. 561)	J. Hoffmeister	3	4	W
2174575	E	Foundry Technology (p. 594)	C. Wilhelm	2	4	S
2117095	E	Basics of Technical Logistics (p. 612)	M. Mittwollen, J. Oellerich	4	6	W
2109021	E	Human-oriented Productivity Management: Personnel Management (p. 624)	P. Stock	2	4	W
2109042	E	Introduction to Industrial Production Economics (p. 631)	S. Dürrschnabel	2	4	W
2150601	E	Integrative Strategies in Production and Development of High Performance Cars (p. 641)	K. Schlichtenmayer	2	4	S
2118097	E	Warehousing and distribution systems (p. 661)	K. Furmans	2	4	S
2145184	E	Leadership and Management Development (p. 664)	A. Ploch	2	4	W
2149612	E	Learning Factory “Global Production“ (p. 667)	G. Lanza	2	4	W
2118085	E	Automotive Logistics (p. 670)	K. Furmans	2	4	S
2149669	E	Materials and Processes for Body Lightweight Construction in the Automotive Industry (p. 681)	D. Steegmüller, S. Kienzle	2	4	W
2117059	EM	Mathematical models and methods for Production Systems (p. 689)	K. Furmans, M. Rimmele	4	6	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2109034	E	Planning of Assembly Systems (in German) (p. 733)	E. Haller	2	4	W
2121366	E	PLM in the Manufacturing Industry (p. 736)	G. Meier	2	4	W
2183640	E (P)	Laboratory “Laser Materials Processing” (p. 746)	J. Schneider, W. Pfleging	3	4	W/S
2110032	E	Production Planning and Control (p. 759)	A. Rinn	2	4	W
2110678	E (P)	Production Techniques Laboratory (p. 760)	K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL	3	4	S

ID	Cat	Course	Lecturer	h	CP	Term
2110046	E	Productivity Management in Production Systems (p. 762)	S. Stowasser	2	4	S
2149680	E	Project Mikro Manufacturing: Design and Manufacturing of Micro Systems (p. 765)	V. Schulze, B. Matuschka, A. Kacaras	3	6	W
2113072	E	Development of Oil-Hydraulic Powertrain Systems (p. 766)	G. Geerling, S. Becker	2	4	W
2149667	E	Quality Management (p. 771)	G. Lanza	2	4	W
2173571	E	Welding Technology (p. 788)	M. Farajian	2	4	W
2150683	E	Control Technology (p. 806)	C. Gönnheimer	2	4	S
2174579	E	Technology of steel components (p. 828)	V. Schulze	2	4	S
2150681	E	Metal Forming (p. 843)	T. Herlan	2	4	S
2149655	E	Gear Cutting Technology (p. 853)	M. Klaiber	2	4	W
2150550	E (P)	Laboratory Production Metrology (p. 752)	B. Häfner	3	4	S
2151643	E	Seminar Data Mining in Production (p. 792)	G. Lanza	2	3	W/S

Conditions: None
Recommendations:
Learning Outcomes: The students . . .

- are able to analyze new situations and choose methods of production science target-oriented based on the analyses, as well as justifying their selection.
- are able to describe and compare complex production processes exemplarily.
- are able to generate new solutions in the field of production science under consideration of scientific theories, principles and methods.
- are able to solve tasks in the field of production science team oriented and proceed responsible and adequate to the situation.
- are able to integrate the results of others at the solution of given problems.
- have the ability to state results in written form developed in a team, and are able to interpret and present them with self-chosen methods.
- are able to identify, dissect and develop further systems and processes and apply given sets of criteria under consideration of technical, economic and social conditions.

Remarks: None

SP 40: Robotics

ID	Cat	Course	Lecturer	h	CP	Term
2105016	K	Computational Intelligence (p. 521)	R. Mikut, W. Jakob, M. Reischl	2	4	W
2106014	K	Data Analytics for Engineers (p. 522)	R. Mikut, M. Reischl, J. Stegmaier	3	5	S
2105011	K	Introduction into Mechatronics (p. 538)	M. Reischl, M. Lorch	3	6	W
2138340	K	Automotive Vision (eng.) (p. 573)	C. Stiller, M. Lauer	3	6	S
24152	K	Robotics I – Introduction to robotics (p. 782)	R. Dillmann, T. Asfour	2	6	W
24644	K	Robotik II: Humanoide Robotic (p. 783)	R. Dillmann, T. Asfour	2	3	S
2138336	K	Behaviour Generation for Vehicles (p. 848)	C. Stiller, M. Werling	2	4	S
2145150	E	Powertrain Systems Technology B: Stationary Machinery (p. 478)	A. Albers, S. Ott	2	4	W
2150904	E	Automated Manufacturing Systems (p. 496)	J. Fleischer	6	8	S
2137309	E	Digital Control (p. 528)	M. Knoop	2	4	W
2138341	E	Cogitive Automobiles - Laboratory (p. 653)	C. Stiller, M. Lauer	3	6	S
2146190	E	Lightweight Engineering Design (p. 657)	A. Albers, N. Burkardt	2	4	S
24613	E	Localization of Mobile Agents (p. 672)	U. Hanebeck	3	4	S
2137308	E	Machine Vision (p. 673)	C. Stiller, M. Lauer	4	8	W
2117059	EM	Mathematical models and methods for Production Systems (p. 689)	K. Furmans, M. Rimmele	4	6	W
2105014	E (P)	Laboratory mechatronics (p. 693)	C. Stiller, M. Lorch, W. Seemann	3	4	W
2138326	E	Measurement II (p. 696)	C. Stiller	2	4	S
2105024	E	Modern Control Concepts I (p. 709)	J. Matthes, L. Gröll	2	4	S
2141865	E	Novel actuators and sensors (p. 717)	M. Kohl, M. Sommer	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2137306	E (P)	Lab Computer-aided methods for measurement and control (p. 747)	C. Stiller, M. Spindler	3	4	W
24890	E (P)	Practical course: Humanoid Robots (p. 751)	T. Asfour	2	3	W
2162216	E	Computerized Multibody Dynamics (p. 776)	W. Seemann	2	4	S
24635	E	Robotik III - Sensors in Robotics (p. 784)	R. Dillmann, Meißner, Gonzalez, Aguirre	2	3	S
2150683	E	Control Technology (p. 806)	C. Gönnheimer	2	4	S
2146192	E	Sustainable Product Engineering (p. 818)	K. Ziegahn	2	4	S
2106033	E	System Integration in Micro- and Nanotechnology (p. 819)	U. Gengenbach	2	4	S
2106002	E	Computer Engineering (p. 823)	M. Lorch, H. Keller	3	6	S
2123375	E	Virtual Reality Laboratory (p. 858)	J. Ovtcharova	3	4	W/S
2150550	E (P)	Laboratory Production Metrology (p. 752)	B. Häfner	3	4	S
2105032	E	Micro- and nanosystem integration for medical, fluidic and optical applications (p. 700)	L. Koker, U. Gengenbach, I. Sieber	2	4	W

Conditions:
Recommendations: Recommended courses:

- 2147175 CAE-Workshop
- 2105011 Einführung in die Mechatronik

Learning Outcomes: The Robotics offers extensive knowledge to develop, design and manufacture future intelligent robots. The following scientific disciplines are covered during the major Robotics:

- Control systems and control theory
- Actuators and sensors
- Mathematical and descriptive methods

The students of the major Robotics have the essential skills necessary to develop future robotic systems for modern applications.
Remarks:

SP 41: Fluid Dynamics

ID	Cat	Course	Lecturer	h	CP	Term
2154446	K	Experimental Fluid Mechanics (p. 559)	J. Kriegseis	2	4	S
2154200	K	Gasdynamics (p. 588)	F. Magagnato	2	4	W
2154437	K	Hydrodynamic Stability: From Order to Chaos (p. 629)	A. Class	2	4	S
2153441	K	Numerical Fluid Mechanics (p. 726)	F. Magagnato	2	4	W
2154044	K	Scaling in fluid dynamics (p. 803)	L. Bühler	2	4	S
2153438	K	Vortex Dynamics (p. 870)	J. Kriegseis	2	4	W
2154420	E	Aerodynamics (p. 468)	F. Ohle, B. Frohnapfel	2	4	S
2154436	E	Aerothermodynamics (p. 469)	F. Seiler, B. Frohnapfel	2	4	S
2169459	E (P)	CFD-Lab using Open Foam (p. 517)	R. Koch	3	4	W
2153405	E	Finite Difference Methods for numerial solution of thermal and fluid dynamical problems (p. 527)	C. Günther	2	4	W
2157444	E (P)	Introduction to numerical fluid dynamics (p. 540)	B. Pritz	2	4	W
2154431	E	Finite Volume Methods for Fluid Flow (p. 581)	C. Günther	2	4	S
6221806	E	Fluid Mechanics of Turbulent Flows (p. 582)	M. Uhlmann	2	4	S
2154401	E	Fluid-Structure-Interaction (p. 583)	M. Mühlhausen, B. Frohnapfel	2	4	S
19228	E	Building- and Environmental Aerodynamics (p. 590)	B. Ruck	2	4	S
2153410	E	Optical Flow Measurement: Fundamentals and Applications (p. 615)	F. Seiler, B. Frohnapfel	2	4	W
2153425	E	Industrial aerodynamics (p. 630)	T. Breitling, B. Frohnapfel	2	4	W
2153429	E	Magnetohydrodynamics (p. 675)	L. Bühler	3	6	W
2154432	E	Mathematical Methods in Fluid Mechanics (p. 686)	B. Frohnapfel, D. Gatti	3	6	S
2130934	E	Numerical Modeling of Multiphase Flows (p. 723)	M. Wörner	2	4	S
2169458	E	Numerical simulation of reacting two phase flows (p. 724)	R. Koch	2	4	W
2153449	E	Numerical Simulation of Turbulent Flows (p. 725)	G. Grötzbach	3	4	W
2154409	E (P)	Numerical Fluid Mechanics with MATLAB (p. 727)	B. Frohnapfel	2	4	S
2153406	E	Flows with chemical reactions (p. 810)	A. Class	2	4	W
2189910	E	Flows and Heat Transfer in Energy Technology (p. 811)	X. Cheng	2	4	W
2154447	E (P)	Flow Simulations (p. 812)	C. Bruzzese, B. Frohnapfel	2	4	W
2189423	E	Thermal-Fluid-Dynamics (p. 836)	S. Ruck	2	4	W
2157381	E	Windpower (p. 869)	N. Lewald	2	4	W
2169470	E	Two-Phase Flow and Heat Transfer (p. 874)	T. Schulenberg, M. Wörner	2	4	W

Conditions:
Recommendations: Subjects are to be selected in such a way that numerical, experimental and theoretical methods are covered.
Learning Outcomes: After having completed this module the student is capable of deriving the relevant fluid mechanical equations and interpret the governed physics. He/She can describe the characteristic properties of fluids and can analyze flow scenarios. According to the chosen lectures, the student can capture flow scenarios with analytical, numerical and/or experimental means and is capable to evaluate the acquired results thoroughly.
Remarks: Only one of the following courses can be chosen within 16LP of SP41:

- Numerical Fluid Mechanics
- Differenzenverfahren zur numerischen Lösung von thermischen und fluid-dynamischen Problemen

- Finite-Volumen-Methoden (FVM) zur Strömungsberechnung

If you wish to choose two of these courses please contact Prof. Frohnapfel.
Within SP41 it is generally possible to also attend further lectures of the Institute of Hydromechanics (www.ifh.kit.edu). These include

- numerical flow simulations I
- numerical flow simulations II
- experimental techniques I

Please contact Prof. Frohnapfel (bettina.frohnapfel@kit.edu) for further information if you are interested in this option.

SP 43: Technical Ceramics and Powder Materials

ID	Cat	Course	Lecturer	h	CP	Term
2193010	K	Basic principles of powder metallurgical and ceramic processing (p. 603)	G. Schell, R. Oberacker	2	4	W
2125757	K	Introduction to Ceramics (p. 648)	M. Hoffmann	4	6	W
2126810	K	Ceramic Matrix Composites (p. 649)	D. Koch	2	4	W
2126775	K	Structural Ceramics (p. 815)	M. Hoffmann	2	4	S
2126811	E	Bionic Inspired Reinforced Composites (p. 510)	D. Koch	2	4	S
2126730	E	Ceramics Processing (p. 650)	J. Binder	2	4	S
2125751	E (P)	Practical Course Technical Ceramics (p. 749)	R. Oberacker	2	4	W
2126749	E	Advanced powder metals (p. 770)	R. Oberacker	2	4	S
2125763	E	Structural and phase analysis (p. 813)	S. Wagner, M. Hinterstein	2	4	W
2181711	E	Failure of structural materials: deformation and fracture (p. 851)	P. Gumbsch, D. Weygand, O. Kraft	3	4	W

Conditions: none
Recommendations: Recommended compulsory elective subjects:

- Systematic Materials Selection
- Physics for Engineers
- Physical basics of laser technology

Learning Outcomes: The students acquire comprehensive and fundamental knowledge of preparation, processing and characterization of technical powders, their consolidation by various shaping techiques and the densification by sintering. They know the manifold possibilities of microstructural design of powdermetallurgical parts and are able to discuss the microstructure property relationships.
Remarks:

SP 44: Technical Logistics

ID	Cat	Course	Lecturer	h	CP	Term
2117095	KP	Basics of Technical Logistics (p. 612)	M. Mittwollen, J. Oellerich	4	6	W
2118087	K	Selected Applications of Technical Logistics (p. 487)	M. Mittwollen, V. Milushev	3	4	S
2118088	K	Selected Applications of Technical Logistics - Project (p. 488)	M. Mittwollen, V. Milushev	2	2	S
2117096	K	Elements of Technical Logistics (p. 543)	M. Mittwollen, G. Fischer	3	4	W
2117097	K	Elements of Technical Logistics - Project (p. 544)	M. Mittwollen, G. Fischer	4	2	W
2150904	E	Automated Manufacturing Systems (p. 496)	J. Fleischer	6	8	S
2117500	E	Energy efficient intralogistic systems (p. 547)	M. Braun, F. Schönung	2	4	W
2118183	EM	IT-Fundamentals of Logistics (p. 646)	F. Thomas	2	4	S
2138341	E	Cogitive Automobiles - Laboratory (p. 653)	C. Stiller, M. Lauer	3	6	S
2118097	E	Warehousing and distribution systems (p. 661)	K. Furmans	2	4	S
2117051	E	Material flow in logistic systems (p. 679)	K. Furmans	4	6	W
2500005	E	Production and Logistics Controlling (p. 758)	H. Wlcek	2	3	W
2149667	E	Quality Management (p. 771)	G. Lanza	2	4	W
2117061	E	Safety Engineering (p. 795)	H. Kany	2	4	W
2138336	E	Behaviour Generation for Vehicles (p. 848)	C. Stiller, M. Werling	2	4	S

Conditions: none
Recommendations: Recommended compulsory optional subjects:

- Mathematical Methods in Dynamics
- Simulation of production systems and processes
- Stochastics in Mecanical Engineering
- Modelling and Simulation
- Technical Logistics I

Learning Outcomes: Students are able to:

- Describe main functional elements of of technical logistics,
- Determine the main parameters necessary for functionality,
- Combines those functional elements to solve material handling tasks appropriate, and
- Evalute resulting material handling installations.

Remarks: If LV 2117095 (basics of technical logistics) has been already examined sucessfully outside this emphasis module, another lecture from core-section can be chosen.

SP 45: Engineering Thermodynamics

ID	Cat	Course	Lecturer	h	CP	Term
2165515	K	Fundamentals of Combustion I (p. 613)	U. Maas	2	4	W
2166538	K	Fundamentals of Combustion II (p. 614)	U. Maas	2	4	S
2167523	K	Modeling of Thermodynamical Processes (p. 708)	R. Schießl, U. Maas	3	6	W/S
2189910	K	Flows and Heat Transfer in Energy Technology (p. 811)	X. Cheng	2	4	W
2167541	E	Selected chapters of the combustion fundamentals (p. 490)	U. Maas	2	4	W/S
2190920	E	Experimental techniques in thermo- and fluid-dynamics (p. 562)	X. Cheng	2	4	S
2154200	E	Gasdynamics (p. 588)	F. Magagnato	2	4	W
2165525	E	Mathematical models and methods in combustion theory (p. 688)	V. Bykov, U. Maas	2	4	W
2134134	E	Analysis tools for combustion diagnostics (p. 697)	J. Pfeil	2	4	S
2166543	E	Reduction methods for the modeling and the simulation of combustion processes (p. 779)	V. Bykov, U. Maas	2	4	S
2153406	E	Flows with chemical reactions (p. 810)	A. Class	2	4	W
2169453	E	Thermal Turbomachines I (p. 833)	H. Bauer	3	6	W
2170476	E	Thermal Turbomachines II (p. 834)	H. Bauer	3	6	S
2167048	E	Combustion diagnositics (p. 845)	R. Schießl, U. Maas	2	4	W/S
2133113	E	Combustion Engines I (p. 846)	H. Kubach, T. Koch	3	4	W
2166534	E	Heatpumps (p. 860)	H. Wirbser, U. Maas	2	4	S

Conditions: None.
Recommendations: Recommended Course:

- 22512 Heat- and Mass transfer

Learning Outcomes: After completion of SP 45 students are able to:

- apply the thermodynamic fundamentals of irreversible processes.
- explain the governing processes in combustion.
- outline the fundamentals of modeling and simulation of reacting flows.
- understand the working principle of technical systems applying thermodynamic processes and combustion.

Remarks:

SP 46: Thermal Turbomachines

ID	Cat	Course	Lecturer	h	CP	Term
2169453	KP	Thermal Turbomachines I (p. 833)	H. Bauer	3	6	W
2170476	K	Thermal Turbomachines II (p. 834)	H. Bauer	3	6	S
2181745	E	Design of highly stresses components (p. 493)	J. Aktaa	2	4	W
2154446	E	Experimental Fluid Mechanics (p. 559)	J. Kriegseis	2	4	S
2170490	E	Combined Cycle Power Plants (p. 587)	T. Schulenberg	2	4	S
2154200	E	Gasdynamics (p. 588)	F. Magagnato	2	4	W
2146190	E	Lightweight Engineering Design (p. 657)	A. Albers, N. Burkardt	2	4	S
2170463	E	Cooling of thermally high loaded gas turbine components (p. 660)	H. Bauer, A. Schulz	2	4	S
2161224	E	Machine Dynamics (p. 677)	C. Proppe	3	5	S
2162220	E	Machine Dynamics II (p. 678)	C. Proppe	2	4	W
2169458	E	Numerical simulation of reacting two phase flows (p. 724)	R. Koch	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2171488	E (P)	Workshop on computer-based flow measurement techniques (p. 750)	H. Bauer	3	4	W/S
2169550	E	Reliability Engineering 1 (p. 780)	A. Konnov	2	3	S
2173585	E	Fatigue of Metallic Materials (p. 790)	K. Lang	2	4	W
2117061	E	Safety Engineering (p. 795)	H. Kany	2	4	W
2170491	E (P)	Simulator Exercises Combined Cycle Power Plants (p. 802)	T. Schulenberg	2	2	S
2161212	E	Vibration Theory (p. 825)	A. Fidlin	3	5	W
2169462	E	Turbine and compressor Design (p. 841)	H. Bauer, A. Schulz	2	4	W
2170478	E	Turbo Jet Engines (p. 842)	H. Bauer, A. Schulz	2	4	S
2181715	E	Failure of Structural Materials: Fatigue and Creep (p. 849)	P. Gruber, P. Gumbsch, O. Kraft	2	4	W
2181711	E	Failure of structural materials: deformation and fracture (p. 851)	P. Gumbsch, D. Weygand, O. Kraft	3	4	W
2153438	E	Vortex Dynamics (p. 870)	J. Kriegseis	2	4	W

Conditions: None.
Recommendations: Recommended Course:

- 22512 Heat- and Mass transfer

Learning Outcomes: After completion of SP 46 students are able to:

- identify and quantify the specific requirements of different applications in the fields of energy technology, aeronautics, car and motor technology and process technology on thermal turbo machines,
- apply the basics of thermodynamics, fluid mechanics and of other generic disciplines to analyse and design turbo machines and their components,
- explain the governing processes in turbo machines such as compression, combustion and expansion,
- Recognise and exploit the potentials to further improve the economics and environmental friendliness of turbo machines, their components and in their interaction with the overarching systems, like power plant or airplane,

Explain the operational principle of turbo machines and the related generics.
Remarks:

SP 47: Tribology

ID	Cat	Course	Lecturer	h	CP	Term
2181114	K	Tribology (p. 839)	M. Dienwiebel	5	8	W
2145181	E	Applied Tribology in Industrial Product Development (p. 474)	A. Albers, B. Lorentz	2	4	W
2146180	E	Powertrain Systems Technology A: Automotive Systems (p. 477)	A. Albers, S. Ott	2	4	S
2181740	E	Atomistic simulations and molecular dynamics (p. 483)	C. Brandl, P. Gumbsch	2	4	S
2194643	E	Constitution and Properties of Wear resistant materials (p. 484)	S. Ulrich	2	4	S
2181220	E	Contact Mechanics (p. 658)	C. Greiner	2	4	S
2142861	E	Nanotechnology for Engineers and Natural Scientists (p. 714)	H. Hölscher, M. Dienwiebel, S. Walheim	2	4	S
2182712	E	Nanotribology and -Mechanics (p. 716)	M. Dienwiebel	2	4	W/S
2173590	E	Polymer Engineering I (p. 737)	P. Elsner	2	4	W
2182115	E (P)	Practical Course “Tribology” (p. 748)	J. Schneider, M. Dienwiebel	3	4	S
2182572	E	Failure Analysis (p. 786)	C. Greiner, J. Schneider	2	4	W
2177618	E	Superhard Thin Film Materials (p. 816)	S. Ulrich	2	4	W

Conditions: none
Recommendations: preliminary knowlegde in mathematics, mechanics and materials science
Learning Outcomes: After attending the core subject “tribology” (2181114) the students have the following skills:

- They can describe the fundamental friction and wear mechanisms, which occur in tribologically stressed systems.
- They can evaluate the friction and wear behavior of tribological systems.
- They can explain the effects of lubricants and their most important additives.
- They can identify suitable approaches to optimize tribological systems.
- They explain the most important experimental methods for the measurement of friction and wear, and is able to use them for the characterisation of tribo pairs.
- They can choose suitable methods for the evaluation of roughness and topography from the nm-scale to the mm-scale and is able to interpret the determined values in respect to their effect on the tribological behavior.
- The can describe the most important surface-analytical methods and their physical principles for the characterization of tribologically stressed sliding surfaces.

The additional learning outcomes depend on which further lectures are selected and are explicitly described there.
Remarks:

SP 49: Reliability in Mechanical Engineering

ID	Cat	Course	Lecturer	h	CP	Term
2181715	K	Failure of Structural Materials: Fatigue and Creep (p. 849)	P. Gruber, P. Gumbsch, O. Kraft	2	4	W
2181711	K	Failure of structural materials: deformation and fracture (p. 851)	P. Gumbsch, D. Weygand, O. Kraft	3	4	W
2182735	E	Application of advanced programming languages in mechanical engineering (p. 479)	D. Weygand	2	4	S
2181740	E	Atomistic simulations and molecular dynamics (p. 483)	C. Brandl, P. Gumbsch	2	4	S
2181745	E	Design of highly stresses components (p. 493)	J. Aktaa	2	4	W
2162282	E	Introduction to the Finite Element Method (p. 535)	T. Böhlke	4	5	S
2182732	E	Introduction to Theory of Materials (p. 537)	M. Kamlah	2	4	S
2181731	E	Fatigue of Welded Components and Structures (p. 556)	M. Farajian, P. Gumbsch,	2	4	W
2183716	E (P)	FEM Workshop – constitutive laws (p. 575)	K. Schulz, D. Weygand	2	4	W/S
2182731	E (P)	Finite Element Workshop (p. 580)	C. Mattheck, D. Weygand, I. Tesari	2	4	S
2181720	E	Foundations of nonlinear continuum mechanics (p. 610)	M. Kamlah	2	4	W
2161252	E	Advanced Methods in Strength of Materials (p. 623)	T. Böhlke	4	4	W
2146190	E	Lightweight Engineering Design (p. 657)	A. Albers, N. Burkardt	2	4	S
2161254	E	Mathematical Methods in Strength of Materials (p. 684)	T. Böhlke	3	5	W
2162280	E	Mathematical Methods in Structural Mechanics (p. 687)	T. Böhlke	3	5	S
2181710	E	Mechanics in Microtechnology (p. 692)	P. Gruber, C. Greiner	2	4	W
2183702	E	Modelling of Microstructures (p. 702)	A. August, B. Nestler, D. Weygand	3	5	W
2181750	E	Multi-scale Plasticity (p. 734)	K. Schulz, C. Greiner	2	4	W
2149667	E	Quality Management (p. 771)	G. Lanza	2	4	W
2182572	E	Failure Analysis (p. 786)	C. Greiner, J. Schneider	2	4	W
2173585	E	Fatigue of Metallic Materials (p. 790)	K. Lang	2	4	W
2117061	E	Safety Engineering (p. 795)	H. Kany	2	4	W
2182740	E	Materials modelling: dislocation based plasticity (p. 866)	D. Weygand	2	4	S
2181738	E	Scientific computing for Engineers (p. 871)	D. Weygand, P. Gumbsch	2	4	W

Conditions: none
Recommendations: preliminary knowlegde in mathematics, mechanics and materials science
Learning Outcomes: After attending the core subjects “failure of structural materials: fatigue and creep” (2181715) and “failure of structural materials: deformation and fracture”(2181711) the students will gain the following skills:

- They have the basic understanding of mechanical processes to explain the relationship between externally applied load and materials strength.
- They can explain the foundation of linear elastic fracture mechanics and is able to determine if this concept can be applied to a failure by fracture.

- They can decribe the main empirical materials models for fatigue and creep as well as for deformation and fracture and can apply them.
- They have the physical understanding to describe and explain phenomena of failure.
- They can use statistical approaches for reliability predictions.
- They can use its acquired skills, to select and develop materials for specific applications.

The additional learning outcomes depend on which further lectures are selected and are explicitly described there.
Remarks:

SP 50: Rail System Technology

ID	Cat	Course	Lecturer	h	CP	Term
2115919	KP	Rail System Technology (p. 499)	P. Gratzfeld	2	4	W/S
2115996	KP	Rail Vehicle Technology (p. 787)	P. Gratzfeld	2	4	W/S
2138340	E	Automotive Vision (eng.) (p. 573)	C. Stiller, M. Lauer	3	6	S
2114914	E	Railways in the Transportation Market (p. 526)	P. Gratzfeld	2	4	S
2114346	E	Electric Rail Vehicles (p. 542)	P. Gratzfeld	2	4	S
2113102	E	Vehicle Lightweight design – Strategies, Concepts, Materials (p. 570)	F. Henning	2	4	W
2114053	E	Composite Manufacturing – Polymers, Fibers, Semi-Finished Products, Manufacturing Technologies (p. 574)	F. Henning	2	4	S
2115995	E	Project Management in Rail Industry (p. 767)	P. Gratzfeld	2	4	W
2162256	E	Computational Vehicle Dynamics (p. 775)	C. Proppe	2	4	S
2115009	E	Seminar for Rail System Technology (p. 793)	P. Gratzfeld	2	3	W/S

Conditions:
Recommendations: none
Learning Outcomes:

- The students understand relations and interdependencies between rail vehicles, infrastructure and operation in a rail system.
- Based on operating requirements and legal framework they derive the requirements concerning a capable infrastructure and suitable concepts of rail vehicles.
- They recognize the impact of alignment, understand the important function of the wheel-rail-contact and estimate the impact of driving dynamics on the operating program.
- They evaluate the impact of operating concepts on safety and capacity of a rail system.
- The students are familiar with concept and structure of modern rail vehicles.
- They learn about advantages and disadvantages of different types of traction drives and judge which one fits best for each application.
- They understand brakes from a vehicular and an operational point of view. They assess the fitness of different brake systems.
- They know about the basics of running dynamics and bogies.
- They define suitable vehicle concepts based on requirements for modern rail vehicles and are able to assess their fitness for the required mode of operation.
- Supplementary lectures present further major aspects of a rail system.

Remarks:

SP 51: Development of innovative appliances and power tools

ID	Cat	Course	Lecturer	h	CP	Term
2145164	KP	Appliance and Power Tool Design (p. 593)	S. Matthiesen	4	8	S
2147175	E	CAE-Workshop (p. 514)	A. Albers, Assistenten	3	4	W/S
2174571	E	Design with Plastics (p. 656)	M. Liedel	2	4	S
2146190	E	Lightweight Engineering Design (p. 657)	A. Albers, N. Burkardt	2	4	S
2145184	E	Leadership and Management Development (p. 664)	A. Ploch	2	4	W
2105014	E (P)	Laboratory mechatronics (p. 693)	C. Stiller, M. Lorch, W. Seemann	3	4	W
2142881	EM	Microactuators (p. 701)	M. Kohl	2	4	S
2141865	E	Novel actuators and sensors (p. 717)	M. Kohl, M. Sommer	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2113072	E	Development of Oil-Hydraulic Powertrain Systems (p. 766)	G. Geerling, S. Becker	2	4	W
2145182	E	Project management in Global Product Engineering Structures (p. 768)	P. Gutzmer	2	4	W
2149667	E	Quality Management (p. 771)	G. Lanza	2	4	W
2146198	E	Strategic product development - identification of potentials of innovative products (p. 809)	A. Siebe	2	4	S

Conditions: SP 51 is not selectable in bachelor degree course.
It is selectable in masters course, depending on specialization.
Due to organizational reasons, the number of participants is limited. At the beginning of august, a registration form will be available at the IPEK website. In the case of too many applicants, a selection process will be taking place. An early application is advantageous.
Recommendations: CAE Workshop is recommended as elective course or complementary subject.
Learning Outcomes: Graduates are able to analyze and to synthesize complex technical products under consideration of customer, business and market demands. Specifically, they can address specific boundary conditions of devices and power tool manufacturers in power-tool development They and are able to take into account the resulting effects of complex product development projects: e.g. the production in large quantities, complexity of mechatronic solutions or workflow management of interdisciplinary and distributed development teams. The graduates are able to assess and optimize their work results in terms of quality, costs and user benefits. They have a holistic insight into the processes that are necessary for creating products in this specific context and thus are prepared for the technical and non-technical requirements of responsible positions in the team-oriented product development of devices and power tools.
Remarks:

SP 53: Fusion Technology

ID	Cat	Course	Lecturer	h	CP	Term
2169483	K	Fusion Technology A (p. 585)	R. Stieglitz, Fietz, Day, Boccaccini	2	4	W
2190492	K	Fusion Technology B (p. 586)	R. Stieglitz, Fischer, Möslang, Gantenbein	2	4	S
23271	K	Radiation Protection: Ionising Radiation (p. 808)	B. Breustedt, M. Urban	2	4	W
2181745	E	Design of highly stresses components (p. 493)	J. Aktaa	2	4	W
2130910	E	CFD for Power Engineering (p. 516)	I. Otic	2	4	S
2189404	E	A holistic approach to power plant management (p. 523)	M. Seidl, R. Stieglitz	2	4	W
2129901	E	Energy Systems I: Renewable Energy (p. 551)	R. Dagan	3	6	W
2190496	E	Magnet Technology of Fusion Reactors (p. 674)	W. Fietz, K. Weiss	2	4	S
2153429	E	Magnetohydrodynamics (p. 675)	L. Bühler	3	6	W
2189473	E	Neutron physics of fusion reactors (p. 719)	U. Fischer	2	4	W
2189904	E	Ten lectures on turbulence (p. 829)	I. Otic	2	4	W
2194650	E	Materials under high thermal or neutron loads (p. 830)	A. Möslang, J. Reiser	2	4	S
2189423	E	Thermal-Fluid-Dynamics (p. 836)	S. Ruck	2	4	W
2169470	E	Two-Phase Flow and Heat Transfer (p. 874)	T. Schulenberg, M. Wörner	2	4	W
2190499	E	Vacuum and Tritium Technology in Nuclear Fusion (p. 844)	C. Day, B. Bornschein	2	4	S

Conditions:
Recommendations: The choice of this topic necessitates a substantial knowledge of the fundamental skills supplied in the bachelor curriculum, such as fluid mechanics, heat and mass transfer, technical thermodnaymics, measurement and control technics, material sciences and design of technical components. Only this basis allows to get access to the often coupled multi-physics problems an enabling the elaboration of a sound solution.
Additional skills in physics and electrical engineering are appreciated
Learning Outcomes: Graduate in fusion technology acquire a fundamental knowledge of the fusion process and are enabled to deduce based on the physical boundary conditions technological and scientific engineering solutions to individual problems. Since fusion technology is intrinsically of interdisciplinary nature consisiting of physics, mechanics, thermal-hydraulics, material sciences and electrical engineering incorporates, the focus of this topic is mainly devoted to allow for the understanding of the underlying physics and moreover to enable the students of couple the different disciplines. Here, mainly mehtodologies and solution approaches are communicated to the gradiuates with the goal to capture critical issues within multi-physics problems, to identify central challenges within the given problem and to enable them to elaborate engineering solution concepts. Aside from the analysis of the relevance/importance of aspects within a complex multi-physics problem graduates are prepared to take decisions based on a solid physics basis and to formulate solution approaches.
The reliable handling of different physical phenomena from different disciplines and the methodological capability to tackle multi-physics questions and to extract from them central core issues qualifies the graduates for a competent and successful career not only in fusion technology but also in neighboring fields such energy energiering as well as process, chemical and environmental engineering both in the research and development context but also in the project management.
Remarks:

SP 54: Microactuators and Microsensors

ID	Cat	Course	Lecturer	h	CP	Term
2142881	K	Microactuators (p. 701)	M. Kohl	2	4	S
2141865	K	Novel actuators and sensors (p. 717)	M. Kohl, M. Sommer	2	4	W
2141866	E	Actuators and sensors in nanotechnology (p. 470)	M. Kohl	2	4	W
2141864	E	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I (p. 506)	A. Guber	2	4	W
2182732	E	Introduction to Theory of Materials (p. 537)	M. Kamlah	2	4	S
2143882	E	Fabrication Processes in Microsystem Technology (p. 576)	K. Bade	2	4	W/S
2141861	E	Introduction to Microsystem Technology I (p. 606)	J. Korvink, V. Badilita, M. Jouda	2	4	W
2142874	E	Introduction to Microsystem Technology II (p. 608)	J. Korvink, M. Jouda	2	4	S
2181710	E	Mechanics in Microtechnology (p. 692)	P. Gruber, C. Greiner	2	4	W
2142897	E	Microenergy Technologies (p. 698)	M. Kohl	2	4	S
2141501	E	Micro Magnetic Resonannce (p. 699)	J. Korvink, N. MacKinnon	2	4	W
2183702	E	Modelling of Microstructures (p. 702)	A. August, B. Nestler, D. Weygand	3	5	W
2142861	E	Nanotechnology for Engineers and Natural Scientists (p. 714)	H. Hölscher, M. Dienwiebel, S. Walheim	2	4	S
24152	E	Robotics I – Introduction to robotics (p. 782)	R. Dillmann, T. Asfour	2	6	W
2106033	E	System Integration in Micro- and Nanotechnology (p. 819)	U. Gengenbach	2	4	S

Conditions: Mechanical Engineering: Major M&M
Recommendations: The major addresses students in the fields of mechanical engineering, mechatronics and information technology, material science and engineering, electrical engineering and industrial engineering. A comprehensive introduction is given in the basics and current developments.
Further information: reference ppt-presentation of the major
Learning Outcomes: **-** Knowledge of the principles of actuation and sensing including pros and cons
- Knowledge of the underlying concepts of materials science and technology
on different lengths scales
- Explanation of layout and function of important actuators and sensors
- Calculation of important properties (time constants, forces, displacements,
sensitivity, etc.)
- Development of a layout based on specifications

Remarks:

SP 55: Energy Technology for Buildings

ID	Cat	Course	Lecturer	h	CP	Term
2157200	KP	Technical energy systems for buildings 1: Processes & components (p. 821)	F. Schmidt	2	4	W
2158203	K	Energy demand of buildings – fundamentals and applications, with building simulation exercises (p. 546)	F. Schmidt	4	6	S
2158201	K	Technical energy systems for buildings 2: System concepts (p. 822)	F. Schmidt	2	4	S
1720970	E	Energy and Indoor Climate Concepts (p. 545)	A. Wagner, wissenschaftl. Mitarbeiter	2	2	S
2189487	E	Energy Storage and Network Integration (p. 549)	R. Stieglitz, W. Jaeger, Jäger, Noe	2	4	W
23380	E	Photovoltaic Systems Technology (p. 730)	N. N.	2	3	S
2169472	E	Thermal Solar Energy (p. 831)	R. Stieglitz	2	4	W
2166534	E	Heatpumps (p. 860)	H. Wirbser, U. Maas	2	4	S
2157381	E	Windpower (p. 869)	N. Lewald	2	4	W
2189423	E	Thermal-Fluid-Dynamics (p. 836)	S. Ruck	2	4	W
2129901	E	Energy Systems I: Renewable Energy (p. 551)	R. Dagan	3	6	W

Conditions:

Recommendations:

Learning Outcomes: After completing the courses in SP 55 „Energy technology for buildings“ the students have achieved a comprehensive overview on the energy demand for air-conditioning of buildings (heating, cooling, humidification, dehumidification, ventilation) and the techniques for energy supply of buildings (heat, cold, locally generated electricity). They know the methods for evaluation of technologies regarding ecologic, criteria, primary energy and economic viability and they have the ability to apply these methods to concrete cases. They also have gained knowledge on all renewable energy technologies that are relevant for application in buildings, in particular solar thermal collectors and systems and photovoltaic systems as well as energy storage technologies that are applied in buildings (heat storage, batteries).

Remarks:

SP 56: Advanced Materials Modelling

ID	Cat	Course	Lecturer	h	CP	Term
2181740	K	Atomistic simulations and molecular dynamics (p. 483)	C. Brandl, P. Gumbsch	2	4	S
2162344	K	Nonlinear Continuum Mechanics (p. 720)	T. Böhlke	2	5	S
2174600	E	High Temperature Materials (p. 622)	M. Heilmaier	2	4	W
2178123	E	Thin film and small-scale mechanical behavior (p. 837)	P. Gruber, D. Weygand, C. Brandl	2	4	S

Conditions:
Recommendations:
Learning Outcomes:
Remarks:

SP 58: Combustion engines based powertrains

ID	Cat	Course	Lecturer	h	CP	Term
2133121	KP	Energy Conversion and Increased Efficiency in Internal Combustion Engines (p. 553)	T. Koch, H. Kubach	2	4	W
2133113	KP	Combustion Engines I (p. 846)	H. Kubach, T. Koch	3	4	W
2134138	K	Fundamentals of catalytic exhaust gas aftertreatment (p. 604)	E. Lox, H. Kubach, O. Deutschmann, J. Grunwaldt	2	4	S
2134134	K	Analysis tools for combustion diagnostics (p. 697)	J. Pfeil	2	4	S
2134137	K	Engine measurement techniques (p. 713)	S. Bernhardt	2	4	S
2134151	K	Combustion Engines II (p. 847)	H. Kubach, T. Koch	3	4	S
2134150	E	Analysis of Exhaust Gas und Lubricating Oil in Combustion Engines (p. 467)	M. Gohl, H. Kubach	2	4	S
2133132	E	Alternative Powertrain for Automobiles (p. 472)	K. Noreikat, H. Kubach	2	4	W
2133112	E	Drive Systems and Possibilities to Increase Efficiency (p. 476)	H. Kollmeier	1	2	W
2181745	E	Design of highly stresses components (p. 493)	J. Aktaa	2	4	W
2150904	E	Automated Manufacturing Systems (p. 496)	J. Fleischer	6	8	S
2113809	E	Automotive Engineering I (eng.) (p. 601)	F. Gauterin, M. Gießler	4	8	W
2133130	E	Numerical Methods for combustion process development (p. 500)	U. Waldenmaier, H. Kubach	1	2	W
2133108	E	Fuels and Lubricants for Combustion Engines (p. 501)	B. Kehrwald, H. Kubach	2	4	W
2113806	E	Vehicle Comfort and Acoustics I (p. 566)	F. Gauterin	2	4	W
2114825	E	Vehicle Comfort and Acoustics II (p. 568)	F. Gauterin	2	4	S
2154200	E	Gasdynamics (p. 588)	F. Magagnato	2	4	W
2134141	E	Gas Engines (p. 589)	R. Golloch	2	4	S
2113805	E	Automotive Engineering I (p. 600)	F. Gauterin, H. Unrau	4	8	W
2114835	E	Automotive Engineering II (p. 602)	H. Unrau	2	4	S
2166538	E	Fundamentals of Combustion II (p. 614)	U. Maas	2	4	S
2161224	E	Machine Dynamics (p. 677)	C. Proppe	3	5	S
2162220	E	Machine Dynamics II (p. 678)	C. Proppe	2	4	W
2134139	E	Model based Application Methods (p. 707)	F. Kirschbaum	3	4	S
2134001	E/P (P)	Engine Laboratory (p. 712)	U. Wagner	2	4	S
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 728)	F. Zacharias	2	4	W/S
2145182	E	Project management in Global Product Engineering Structures (p. 768)	P. Gutzmer	2	4	W
2146192	E	Sustainable Product Engineering (p. 818)	K. Ziegahn	2	4	S
2158107	E	Technical Acoustics (p. 820)	M. Gabi	2	4	S
2181114	E	Tribology (p. 839)	M. Dienwiebel	5	8	W
2133125	E	Ignition systems (p. 873)	O. Toedter	2	4	W
2134153	E	Boosting of Combustion Engines (p. 486)	J. Kech	2	4	S

Conditions: The courses [2113805] and [2113809] can not be combined within this major field.
Recommendations: Recommended Courses:

- 22512 Heat and Mass Transfer
- 2165515 Fundamentals of combustion I

Learning Outcomes: After completion of SP 58 students are able to:

- transfer fundamentals of thermodynamics and technical combustion to applications of combustion engines
- name and describe applications
- describe and explain the working principle of combustion engine and its application in vehicles
- analyze and evaluate propulsion systems

Remarks:

SP 59: Innovation and Entrepreneurship

ID	Cat	Course	Lecturer	h	CP	Term
2545011	K	Design Thinking (p. 524)	O. Terzidis, Dr. Kneisel, Dr. H. Haller, P. Nitschke	2	3	W
2545001	K	Entrepreneurship (p. 554)	O. Terzidis	2	3	W/S
2169466	K	Innovative Project (p. 639)	A. Class, Prof. Dr. O. Terzidis	3	4	W
23684	K	Project Management for Engineers (p. 763)	M. Noe	2	3	S
2545009	E	Business Plan for Founders (p. 512)	O. Terzidis	2	4	W/S
2540464	E	eEnergy: Markets, Services, Systems (p. 533)	C. Weinhardt	2/1	4,5	S
2581012	E	Renewable Energy – Resources, Technology and Economics (p. 781)	R. McKenna	2/0	3,5	W

Conditions: Proof of English proficiency by a test:

- IELTS Academic test
  An overall band score of at least 6.5 (with no section lower than 5.5)
- University of Cambridge
  Certificate in Advanced English, CAE (grades A – C)
  Certificate of Proficiency in English, CPE (grades A – C)
- TOEFL Internet-based test, IBT
  A total score of at least 92, with a minimum score of 22 from the writing section

Recommendations: Recommendet is participation in the lecture entrepreneurship.
Learning Outcomes: After completing the module, the students have theoretical fundamentals and solid understanding of electrical power engineering.
Furthermore they understand and master the analogy between momentum and energy transport. The students can analyse new problems with the aid of the acquired methods.
Furthermore these basic courses enable the students to speak a common language, which is an important prerequisite in the field of energy technologies, which has a pronounced interdisciplinary character.
Remarks:

ID	Cat	Course	Lecturer	h	CP	Term
2161212	K	Vibration Theory (p. 825)	A. Fidlin	3	5	W
2161224	K	Machine Dynamics (p. 677)	C. Proppe	3	5	S
2162241	K	Mathematical methods of vibration theory (p. 685)	W. Seemann	3	5	S
2163113	K	Theory of Stability (p. 805)	A. Fidlin	4	6	S
2162247	K	Introduction to Nonlinear Vibrations (p. 541)	A. Fidlin	4	7	W
2162220	E	Machine Dynamics II (p. 678)	C. Proppe	2	4	W
2161241	E (P)	Schwingungstechnisches Praktikum (p. 791)	A. Fidlin	3	4	S
2161219	E	Wave Propagation (p. 862)	W. Seemann	2	4	W
2163111	E	Dynamics of the Automotive Drive Train (p. 532)	A. Fidlin	4	5	W
2162225	E	Experimental Dynamics (p. 558)	A. Fidlin	3	5	S
2113806	E	Vehicle Comfort and Acoustics I (p. 566)	F. Gauterin	2	4	W
2114856	E	Vehicle Ride Comfort & Acoustics I (eng.) (p. 567)	F. Gauterin	2	4	S
2114825	E	Vehicle Comfort and Acoustics II (p. 568)	F. Gauterin	2	4	S
2162246	E	Computational Dynamics (p. 774)	C. Proppe	2	4	S

Conditions: In the Master's program only selectable for the following areas of specialization:

- Allgemeiner Maschinenbau
- Energie- und Umwelttechnik
- Fahrzeugtechnik
- Mechatronik und Mikrosystemtechnik
- Produktentwicklung und Konstruktion
- Produktionstechnik
- Theoretischer Maschinenbau

Recommendations:
Learning Outcomes: The students know different methods which may be applied for the analysis of investigation of vibration problems. They are able to treat one or multiple degrees of freedom systems as well as vibrating continua. The goal is to establish a chain from physical modeling via mathematical solution to an interpretation of the results. Based on the courses which are chosen the knowledge has emphasis on theoretical investigations, approximation methods or experimental methods and applications in automotive engineering.
Remarks:

ID	Cat	Course	Lecturer	h	CP	Term
2162235	K	Introduction into the multi-body dynamics (p. 539)	W. Seemann	3	5	S
2161224	K	Machine Dynamics (p. 677)	C. Proppe	3	5	S
2161206	K	Mathematical Methods in Dynamics (p. 683)	C. Proppe	2	5	W
2163111	K	Dynamics of the Automotive Drive Train (p. 532)	A. Fidlin	4	5	W
2181740	E	Atomistic simulations and molecular dynamics (p. 483)	C. Brandl, P. Gumbsch	2	4	S
2162241	E	Mathematical methods of vibration theory (p. 685)	W. Seemann	3	5	S
2114095	E	Simulation of Coupled Systems (p. 798)	M. Geimer	4	4	S
2162225	E	Experimental Dynamics (p. 558)	A. Fidlin	3	5	S
2162246	E	Computational Dynamics (p. 774)	C. Proppe	2	4	S
2162216	E	Computerized Multibody Dynamics (p. 776)	W. Seemann	2	4	S
2162220	E	Machine Dynamics II (p. 678)	C. Proppe	2	4	W
2162256	E	Computational Vehicle Dynamics (p. 775)	C. Proppe	2	4	S

Conditions: In the Master's program only selectable for the following areas of specialization:

- Allgemeiner Maschinenbau
- Energie- und Umwelttechnik
- Fahrzeugtechnik
- Mechatronik und Mikrosystemtechnik
- Produktentwicklung und Konstruktion
- Produktionstechnik
- Theoretischer Maschinenbau

Recommendations:
Learning Outcomes: The module provides modeling competences and continues thus the compulsory courses in dynamics. To this end analytical methods for the modeling and examination of dynamical systems are presented. The simulation of the systems enables the students to do simulation studies in typical applications in dynamical systems of mechanical engineering to be able to evaluate and interpret the results.
Remarks:

6 Courses of the Major Fields

6.1 All Courses

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

Coordinators: M. Gohl, H. Kubach
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

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

Learning Control / Examinations
Letter of attendance or oral exam (25 minutes, no auxillary means)

Conditions
none

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

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

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

Media
Lecture with Powerpoint slides

Literature
The lecture documents are distributed during the courses.

Course: Aerodynamics [2154420]

Coordinators: F. Ohle, B. Frohnapfel
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
oral, 30 min,
auxiliary means: none

Conditions
none

Recommendations
Grundlagen der Strömungsmechanik, Mathematische Methoden der Strömungsmechanik

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

Content

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

Literature
J.D. Anderson, jr.. Fundamentals of Aerodynamics, McGraw-Hill
E.L. Houghton. Aerodynamics for Engineering Students, Butterworth-Heinemann (Elsevier)
Schlichting, Gersten. Grenzschichttheorie, Springer

Remarks
Block course with limited number of participants, registration in the secretary's office required.
See details at www.istm.kit.edu.

Course: Aerothermodynamics [2154436]

Coordinators: F. Seiler, B. Frohnapfel
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
none

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

Content

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

Literature
H. Oertel jun.: Aerothermodynamik, Springer-Verlag, Berlin Heidelberg New York,
1994
F. Seiler: Skript zur Vorlesung über Aerothermodynamik

Remarks
Block course with limited number of participants, registration in the secretary's office required. See details at www.istm.kit.edu

Course: Actuators and sensors in nanotechnology [2141866]

Coordinators: M. Kohl
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach]

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

Learning Control / Examinations
as elective subject in major field or as optional subject, oral exam, 30 minutes

Conditions
None.

Recommendations
The lecture addresses students in the fields of mechanical engineering, mechatronics and information technology, materials science and engineering, physics, electrical engineering and economic sciences. A comprehensive introduction is given in the basics and current developments on the nanoscopic length scale.

Learning Outcomes
- Knowledge of the principles of actuation and sensing
- Knowledge of important fabrication technologies
- Explanation of typical properties (time constants, sensitivities, forces, etc.)
- Explanation of layout and function of the actuators and sensors

Content
- Physical principles of actuation and sensing
- Scaling and size effects
- Fabrication technologies
- Selected developments
- Applications

The lecture includes amongst others the following topics:
Nano technologies
Nano electro mechanical systems (NEMS)
Nano magneto mechanical and multiferroic systems
Polymer-based nano actuators
Nano motors, molecular systems
Adaptive nano optical systems
Nanosensors: concepts, materials, fabrication
Examples on different categories of materials and applications:
C-based, MeOx-based nano sensors
Physical, chemical, biological nano sensors
Multivariant data analysis / interpretation

Literature
- Lecture notes
- 2. Balzani, V., Credi, A., & Venturi, M., Molecular devices and machines: concepts and perspectives for the nanoworld, 2008
- „Nanowires and Nanobelts, - Materials, Properties and Devices -, Volume 2: Nanowires and Nanobelts of Functional Materials“, Edited by Zhong Lin Wang, Springer, 2003, ISBN 10 0-387-28706-X
- „Sensors Based on Nanostructured Materials“, Edited by Francisco J. Arregui, Springer, 2009, ISBN: 978-0-387-77752-8
- “Multivariate Datenanalyse – Methodik und Anwendungen in der Chemie”, R. Henrion, G. Henrion, Springer 1994, ISBN 3-540-58188-X

Course: Actual topics of BioMEMS [2143873]

Coordinators: A. Guber
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
active participation and own presentation

Conditions
None.

Recommendations
Participation in lectures BioMEMS 1-3

Learning Outcomes
Knwolede in the actual activities in bio-medical and biological technologies under the view of micro technology. The student gets an overview on actual examples of new applications in BioMEMS.
After successfull participation of this seminar the student is able to prepare a new topic in BioMEMS and to present it to an audience.

Content

Media
Written preparations from the participants.

Course: Alternative Powertrain for Automobiles [2133132]

Coordinators: K. Noreikat, H. Kubach
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
See module specification

Conditions
None.

Learning Outcomes
The Student can name and describe alternative powertrains and fuels. He can explain the interaction of the different systems and the impact of the alternative fuels on the powertrain system.

Content
Historie, Energie Conversion
Legislation, CO_2, Fuel Consumption
Alternative Fuels
Innovative Powertrain Concepts
Hybrid Powertrains
Plug-In-Hybrids
BEV
Fuel Cell Vehicle
Common Components
Infrastructure
Market situation

Course: Analysis and Design of Multisensor Systems [23064]

Coordinators: G. Trommer, G. Trommer
Part of the modules: SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	de

Learning Control / Examinations
Oral exam.

Conditions
None.

Learning Outcomes

Content

Literature
Elective literature:

- Jan Wendel: Integrierte Navigationssysteme : Sensordatenfusion, GPS und Inertiale Navigation, München 2007.
- D. H. Titterton, J. L. Weston: Strapdown Inertial Navigation Technology.
- R. Brown, P. Hwang: Introduction to Random Signals and Applied Kalman Filtering, John Wiley & Sons.
- Farrell, J.; Barth, M.: The Global Positioning System & Inertial Navigation, McGraw-Hill, 1999, New York.
- Grewal, M.S. u.a.: Global Positioning Systems, Inertial Navigation and Integration, John Wiley & Sons, 2001, New York.

Course: Applied Tribology in Industrial Product Development [2145181]

Coordinators: A. Albers, B. Lorentz
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 47: Tribology (p. 453)[SP_47_mach]

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

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The goal of the lecture is to discuss tribological problems, tribological features and the tribological variety on examples of the automobile industry.
The students are able to ...

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

Content
Friction, Wear, Wear Measurement
Lubricant (Oil, Grease, etc.)
Hydrodynamic and elastohydrodynamic Lubrication
Design of Tribologic Working Surface Pairs
Technique of Measurement in Lubricated Contacts
Prevention of Maschine Failure
Protective Surface Layers
Journal Bearings, Roller Bearings
Gear Wheels and Transmissions

Literature
The lecture script will be allocated at Ilias.

Course: Drive Train of Mobile Machines [2113077]

Coordinators: M. Geimer, M. Scherer, D. Engelmann
Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach]

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

Learning Control / Examinations
The final assessment will be an oral examination taking place during the recess period. The examination will be offered in every semester and can be repeated at any regular examination date.

Conditions
None.

Recommendations

- General principles of mechanical engineering
- Basic knowledge of hydraulics
- Interest in mobile machinery

Learning Outcomes
At the end of the lecture, participants can explain the structure and function of all discussed drive trains of mobile machines. They can analyze complex gearbox schematics and synthesize simple transmission functions using rough calculations.

Content
In this course the different drive trains of mobile machinery will be discussed. The focus of this course is:
- mechanical gears
- torque converter
- hydrostatic drives
- power split drives
- eletrical drives
- hybrid drives
- axles
- terra mechanics

Media
projector presentation

Literature
Download of lecture slides from ILIAS. Further literature recommendations during lectures.

Course: Drive Systems and Possibilities to Increase Efficiency [2133112]

Coordinators: H. Kollmeier
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Winter term	de

Learning Control / Examinations
Oral examination, time duration 30 min., no aids

Conditions
none

Recommendations
Verbrennungsmotoren A

Learning Outcomes
The student has an overview about possibilities for increasing the efficiency of propulsion systems. He understands the basics of waste heat recovery and knows the required technology therefore. He has an overview about systems for storage electrical energy, heat energy and mechanical energy. The student understands the technical contexts of combined propulsions systems of internal combustion engine and electric motor/generator. The student understands the necessary of lightweight construction systems and knows the material basics therefore.

Content
The students attend to propulsion systems and possibilities for increasing efficiency and get an overview about the demand of energy of stationary and mobile propulsion systems. Furthermore they get an overview about possibilities for increasing efficiency by the use of storage systems, systems of waste heat recovery and lightweight construction systems. There is also a view on complete systems for increasing efficiency as combined heat and power plant and hybrid propulsion systems.

Media
Lecture with powerpoint slides

Literature
Download of powerpoint slides

Remarks
none

Course: Powertrain Systems Technology A: Automotive Systems [2146180]

Coordinators: A. Albers, S. Ott
Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 47: Tribology (p. 453)[SP_47_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 10: Engineering Design (p. 412)[SP_10_mach]

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

Learning Control / Examinations
The type of examination (written or oral) will be announced at the beginning of the lecture.
written examination: 60 min duration
oral examination: 20 min duration

Conditions
none

Recommendations
Power Train Systems Technology B: Stationary Machinery

Learning Outcomes
The student acquires the basic skills which are necessary to design energy-efficient and comfortable automotive powertrain solutions.

Content
Powertrain System
Driver System
Environment System
System Components
Development Process

Literature
Kirchner, E.; “Leistungsübertragung in Fahrzeuggetrieben: Grundlagen der Auslegung, Entwicklung und Validierung von Fahrzeuggetrieben und deren Komponenten”, Springer Verlag Berlin Heidelberg 2007
Naunheimer, H.; “Fahrzeuggetriebe: Grundlagen, Auswahl, Auslegung und Konstruktion”, Springer Verlag Berlin Heidelberg 2007

Course: Powertrain Systems Technology B: Stationary Machinery [2145150]

Coordinators: A. Albers, S. Ott
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 02: Powertrain Systems (p. 407)[SP_02_mach]

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

Learning Control / Examinations
The type of examination (written or oral) will be announced at the beginning of the lecture.
written examination: 60 min duration
oral examination: 20 min duration

Conditions
none

Recommendations
Powertrain Systems Technology A: Automotive Systems

Learning Outcomes
The student acquires the basic skills which are necessary to design energy-efficient and secure solutions for the design of stationary powertrain applications.

Content
Powertrain System
Operator System
Environment System
System Components
Development Process

Literature
VDI-2241: “Schaltare fremdbetätigte Reibkupplungen und -bremsen”, VDI Verlag GmbH, Düsseldorf
Geilker, U.: “Industriekupplungen - Funktion, Auslegung, Anwendung”, Die Bibliothek der Technik, Band 178, verlag moderne industrie, 1999

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

Coordinators: D. Weygand
Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach]

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

Learning Control / Examinations
oral exam ca. 30 minutes

Conditions
The lecture can not be combined with the course "Scientific Programming for Engineers" (2181738).

Learning Outcomes
The student can

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

Through the accompanying exercises the students are able to apply the content of the lecture.

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

* Fortran 95/2003
- structure of source code
- progamming
- compiling
- debugging
- parallelization with OpenMP
* numerical methods
* script languages: Python, awk
* visualisation
Exercises (2182736, 2 SWS) are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students and for testing progress in learning of the topics.

Literature

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

Course: Human Factors Engineering I: Ergonomics [2109035]

Coordinators: B. Deml
Part of the modules: SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach]

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

Learning Control / Examinations
written exam
The exams are only offered in German!

Conditions
None

Learning Outcomes
The students acquire a basic knowledge in the field of ergonomics:

- They are able to consider cognitive, physiological, anthropometric, and safety technical aspects in order to design workplaces ergonomically.
- Just as well they know physical and psycho-physical fundamentals (e. g. noise, lighting, climate) in the field of work-environmental design.
- Furthermore the students are able to evaluate workplaces by knowing and being able to apply essential methods of time studies and payment systems.
- Finally, they get a first, overall insight into the German labour law as well as into the organisation of advocacy groups beyond companies.

Further on the participants get to know basic methods of behavioral-science data acquisition (e. g. eye-tracking, ECG, dual-task-paradigm).

Content

1. Principles of human work
2. Behavioural-science data acquisition
3. workplace design
4. work environment design
5. work management
6. labour law and advocay groups

Literature
The lecture material is available on ILIAS for download.

Course: Human Factors Engineering II: Work Organisation [2109036]

Coordinators: B. Deml
Part of the modules: SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach]

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

Learning Control / Examinations
written exam
The exams are only offered in German!

Conditions
None.

Learning Outcomes
The students gain a first insight into empirical research methods (e. g. experimental design, statistical data evaluation). Particularly, they acquire a basic knowledge in the field of work organisation:

- *Organizational level.* Within this module the students gain also a fundamental knowledge in the field of structural, process, and production organization.
- *Group level.* Besides, they get to know basic aspects of industrial teamwork and they know relevant theories in the field of interaction and communication, the management of employees as well as work satisfaction and motivation.
- *individual level.* Finally, the students get to know also methods in the field of personnel selection, development, and assessment.

Content

1. Fundamentals of work organization
2. Empirical research methods
3. Individual level
   - personnel selection
   - personnel development
   - personnel assessment
   - work satisfaction/motivation
4. Group level
   - interaction and communication
   - management of employees
   - team work
5. Organizational level
   - structural organization
   - process organization
   - production organization

Literature
The lecture material is available on ILIAS for download.

Course: Human Factors Engineering III: Empirical research methods [2110036]

Coordinators: B. Deml
Part of the modules: SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach]

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

Learning Control / Examinations
Scientific report (about 6 pages), poster, and presentation

Conditions
In order to attend this lecture, it is necessary having completed “Arbeitswissenschaft I” or “Arbeitswissenschaft II” successfully.

Learning Outcomes
For this lecture basic knowledge in work science is assumed, which will be deepened in the course (e. g. in the field of eye-tracking, digital human modeling, driver-vehicle-interaction). Besides the students learn how to design and to carry out experiments and how to analyze the outcome by means of descriptive/inferential statistics. Finally, they are able to present and to discuss the results (e. g. in the form of a scientific report/poster/presentation).

Content

- Introduction into Empirical Research Methods
- Deepening of human factors knowledge (e. g. driver-vehicle-interaction, eye-tracking, digital human modelling)
- Design of an experimental study
- Carrying out an experimental study
- Analyzing the outcome of an experimental study by descriptive/inferential statistics
- Preparing, presenting, and discussing the results (in the form of a scientific report/poster/presentation)

Literature
The lecture material is available on ILIAS for download.

Course: Atomistic simulations and molecular dynamics [2181740]

Coordinators: C. Brandl, P. Gumbsch

Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 56: Advanced Materials Modelling (p. 461)[SP_56_mach], SP 47: Tribology (p. 453)[SP_47_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], (p. 466)[SP_61_mach]

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

Learning Control / Examinations
oral exam ca. 30 minutes

Conditions
compulsory preconditions: none

Recommendations
preliminary knowlegde in mathematics, physics and materials science

Learning Outcomes
The student can

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

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

1. Introduction
2. Physics of Materials
3. MD Basics, Atom-Billard
* particle, position, energy, forces, pair potentials
* initial and boundary conditions
* time integration
4. algorithms
5. statics, dynamics, thermodynamics
6. MD output
7. interaction between particles
* pair potential – many body potentials
* principles of quantum mechanics
* tight binding methods
* dissipative particle dynamics
8. application of particle based methods
Exercises (2181741, 2 SWS) are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students.

Literature

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

Course: Constitution and Properties of Wear resistant materials [2194643]

Coordinators: S. Ulrich
Part of the modules: SP 47: Tribology (p. 453)[SP_47_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
oral examination (30 min)

no tools or reference materials

Conditions
None

Recommendations
None

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

Content
introduction

materials and wear

unalloyed and alloyed tool steels

high speed steels

stellites and hard alloys

hard materials

hard metals

ceramic tool materials

superhard materials

new developments

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

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

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

Copies with figures and tables will be distributed

Course: Constitution and Properties of Protective Coatings [2177601]

Coordinators: S. Ulrich
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
oral examination (30 min)

no tools or reference materials

Conditions
None

Recommendations
None

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

Content
introduction and overview

concepts of surface modification

coating concepts

coating materials

methods of surface modification

coating methods

characterization methods

state of the art of industrial coating of tools and components

new developments of coating technology

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

Copies with figures and tables will be distributed

Course: Boosting of Combustion Engines [2134153]

Coordinators: J. Kech
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach]

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

Learning Control / Examinations
oral exam 20 minutes

Conditions
None.

Learning Outcomes

Content
1 Introduction
2 Working principle of combustion engines
3 Thermodynamics of Supercharging
4 Requirements on Supercharging
5 Conceprs of Supercharging
6 Operation behaviour of supercharged engines
7 Turbocharger concepts
8 Design of turbochargers
9 Construction principles
10 Experimental testing
11 Control concepts
12 Excursion

Media
Slides

Course: Selected Applications of Technical Logistics [2118087]

Coordinators: M. Mittwollen, V. Milushev
Part of the modules: SP 44: Technical Logistics (p. 450)[SP_44_mach]

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

Learning Control / Examinations
after each lesson period; oral / written (if necessary)

Conditions
none

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

Learning Outcomes
Students are able to:

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

Content
design and dimension of machines from intralogistics // static and dynamic behaviour // operation properties and specifics // visit of real intralogistic system
Inside practical lectures: sample applications and calculations in addition to the lectures

Media
supplementary sheets,projector, blackboard

Literature
Recommendations during lessons

Course: Selected Applications of Technical Logistics - Project [2118088]

Coordinators: M. Mittwollen, V. Milushev
Part of the modules: SP 44: Technical Logistics (p. 450)[SP_44_mach]

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

Learning Control / Examinations
Lesson: after each lesson period; oral / written (if necessary)
(counts two-thirds);
Project: presentation, marked (counts one third)

Conditions
none

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

Learning Outcomes
Students are able to:

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

Content
design and dimension of machines from intralogistics // static and dynamic behaviour // operation properties and specifics // visit of real intralogistic system // self manufactured project report
Inside practical lectures: sample applications and calculations in addition to the lectures
Self manufacturing of a project report to recesses the topic.

Media
supplementary sheets,projector, blackboard

Literature
Recommendations during lessons

Course: Selected Topics on Optics and Microoptics for Mechanical Engineers [2143892]

Coordinators: T. Mappes
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
oral exam, 20 min

Conditions
None.

Learning Outcomes

Content

Course: Selected chapters of the combustion fundamentals [2167541]

Coordinators: U. Maas
Part of the modules: SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

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

Learning Control / Examinations
Oral
Duration: 30 min

Conditions
None

Recommendations
None

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

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

Media
Blackboard and Powerpoint presentation

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

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

Coordinators: R. Dagan
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

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

Learning Control / Examinations
oral exam, 30 min.

Conditions
none

Recommendations
none

Learning Outcomes
The students

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

Content

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

Literature
K. Wirtz Basics of Reactor technic Par I, II, Technic School Karlsruhe 1966 (in German)
D. Emendorfer. K.H. Höcker Theory of nuclear reactions, BI- Hochschultaschenbücher 1969 (in German)
J. Duderstadt and L. Hamilton, Nuclear reactor Analysis, J. Wiley $ Sons, Inc. 1975.

Course: Design of a jet engine combustion chamber [22527]

Coordinators: N. Zarzalis
Part of the modules: SP 24: Energy Converting Engines (p. 426)[SP_24_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	2	Winter term	en

Learning Control / Examinations
Certificate

Conditions
Engineering Thermodynamics, Fluid Mechanics, Heat and Mass Transfer, Construction

Recommendations
None.

Learning Outcomes

Content

Remarks
None.

Course: Design of highly stresses components [2181745]

Coordinators: J. Aktaa
Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 53: Fusion Technology (p. 458)[SP_53_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 21: Nuclear Energy (p. 422)[SP_21_mach]

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

Learning Control / Examinations
oral exam: 30 minutes

Conditions
material science
solid mechanics II

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

Content
Contents of the lecture:

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

Literature

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

Course: Design and Development of Mobile Machines [2113079]

Coordinators: M. Geimer, J. Siebert
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach]

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

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.
Required for the participation in the examination is the preparation of a report during the semester.

Conditions
The number of participants is limited. A registration is mandatory, the details will be announced on the webpages of the *Institute of Vehicle System Technology | Institute of Mobile Machines*. In case of too many applications, attendance will be granted based on pre-qualification.

Recommendations
Knowledge in Fluid Power Systems (WiSe, LV 2114093)

Learning Outcomes
After completion of the lecture, studens can:

- design working and travel drive train hydraulics of mobile machines and can derive characteristic key factors.
- choose and apply suitable state of the art designing methods succesfully
- analyse a mobile machine and break its structure down from a complex system to subsystems with reduced complexity
- identify and describe interactions and links between subsystems of a mobile machine
- present and document solutions of a technical problem according to R&D standards

Content
The working scenario of a mobile machine depends strongly on the machine itself. Highly specialised machines, e.g. pavers are also as common as universal machines with a wide range of applications, e.g. hydraulic excavators. In general, all mobile machines are required to do their intended work in an optimal way and satisfy various critera at the same time. This makes designing mobile machines to a great and interesting challenge. Nevertheless, usually key factors can be derived for every mobile machine, which affect all other machine parameters. During this lecture, those key factors and designing mobile machines accordingly will be adressed. To do so, an exemplary mobile machine will be discussed and designed in the lecture an as a semester project.

Literature
See german recommendations.

Remarks
The course will be replenished by interesting lectures of professionals from leading hydraulic companies.

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

Coordinators: H. Faust
Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
Oral Examination

Conditions
none

Learning Outcomes
The students gain the knowledge about ...

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

Content

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

Course: Automated Manufacturing Systems [2150904]

Coordinators: J. Fleischer

Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 04: Automation Technology (p. 409)[SP_04_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	6	Summer term	de

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students . . .

- are able to analyze implemented automated manufacturing systems and describe their components.
- are capable to assess the implemented examples of implemented automated manufacturing systems and apply them to new problems.
- are able to name automation tasks in manufacturing plants and name the components which are necessary for the implementation of each automation task.
- are capable with respect to a given task to plan the configuration of an automated manufacturing system and to determine the necessary components to its realization.
- are able to design and select components for a given use case of the categories: “Handling Technology”, “Industrial Robotics”, “Sensory” and “Controls”.
- are capable to compare different concepts for multi-machine systems and select a suitable concept for a given use case.

Content
The lecture provides an overview of the structure and functioning of automated manufacturing systems. In the introduction chapter the basic elements for the realization of automated manufacturing systems are given. This includes:

- Drive and control technology
- Handling technology for handling work pieces and tools
- Industrial Robotics
- Quality assurance in automated manufacturing
- automatic machines, cells, centers and systems for manufacturing and assembly
- structures of multi-machine systems
- planning of automated manufacturing systems

An interdisciplinary view of these subareas enables Industry 4.0 solutions.
In the second part of the lecture, the basics are illustrated using implemented manufacturing processes for the production of automotive components (chassis and drive technology).The analysis of automated manufacturing systems for manufacturing of defined components is also included.
In the field of vehicle power train both, the automated manufacturing process for the production of the conventional internal-combustion engine and the automated manufacturing process for the production of the prospective electric power train (electric motor and battery) are considered. In the field of car body, the focus is on the analysis of the process chain for the automated manufacturing of conventional sheet metal body parts, as well as for automated manufacturing of body components made out of fiber-reinforced plastics.
Within tutorials, the contents from the lecture are advanced and applied to specific problems and tasks.

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Automation Systems [2106005]

Coordinators: M. Kaufmann
Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 31: Mechatronics (p. 435)[SP_31_mach]

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

Learning Control / Examinations
oral exam

Conditions
None.

Recommendations
Fundamentals of measuring and control engineering

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

Content

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

Literature

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

Course: Rail System Technology [2115919]

Coordinators: P. Gratzfeld
Part of the modules: SP 50: Rail System Technology (p. 456)[SP_50_mach]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes
The students understand relations and interdependencies between rail vehicles, infrastructure and operation in a rail system.
Based on operating requirements and legal framework they derive the requirements concerning a capable infrastructure and suitable concepts of rail vehicles.
They recognize the impact of alignment, understand the important function of the wheel-rail-contact and estimate the impact of driving dynamics on the operating program.
They evaluate the impact of operating concepts on safety and capacity of a rail system.

Content

1. Railway System: railway as system, subsystems and interdependencies, definitions, laws, rules, railway and environment, economic impact
2. Operation: Transportation, public transport, regional transport, long-distance transport, freight service, scheduling
3. Infrastructure: rail facilities, track alignment, railway stations, clearance diagram
4. Wheel-rail-contact: carrying of vehicle mass, adhesion, wheel guidance, current return
5. Vehicle dynamics: tractive and brake effort, driving resistance, inertial force, load cycles
6. Signalling and Control: operating procedure, succession of trains, European Train Control System, blocking period, automatic train control
7. Traction power supply: power supply of rail vehicles, power networks, filling stations
8. History (optional)

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

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

Remarks
none

Course: Numerical Methods for combustion process development [2133130]

Coordinators: U. Waldenmaier, H. Kubach
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Winter term	de

Learning Control / Examinations
oral exam approx. 20 minutes

Conditions
None.

Learning Outcomes
The student can name the simulation processes. he can describe the process flow and explain the method of solution for fundamental problems

Content
Introduction
Working process calculation
Pressure trace analysis
Overall system
Combustion simulation
further CFD applications
Validation methods

Course: Fuels and Lubricants for Combustion Engines [2133108]

Coordinators: B. Kehrwald, H. Kubach
Part of the modules: SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

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

Learning Control / Examinations
oral examination, Duration: ca. 25 min., no auxiliary means, exam dates directly after lecture period

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can name and explain composition and meaning of fuels, lubricants and coolants as important components in the system of todays Otto and Diesel engines as well as definition and chemical composition of fuels and lubricants, the meanig of crude oil as basic primary product, production processes, major properties, standards and specifications, testing methods.
They can point out future worldwide trends in the field of conventional and alternative fuels regarding emission standards and energy conservation

Content
Introduction and basics

Fuels for Gasoline and Diesel engines

Hydrogen

Lubricants for Gasoline and Diesel engines

Coolants for combustion engines

Media
script, will be provided in the lecture

Literature
Lecturer notes

Course: Medical Imaging Techniques I [23261]

Coordinators: O. Dössel
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach]

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

Learning Control / Examinations
Written Exam

Conditions
None.

Recommendations
23275

Learning Outcomes
Comprehensive understanding of all methods of medical imaging based on ionizing radiation
This course teaches students to understand theoretical aspects and engineering of x-ray imaging systems (incl. Computed Tomography) and imaging methods of Nuclear Medicine (SPECT and PET).

Content
X-ray Physics and technique of X-ray imaging
Digital radiography, x-ray image intensifier, flat x-ray detectors
Theory of imaging systems, Modulation-Transfer-Function and Detective Quantum Efficency
Computer Tomography CT
Ionizing radiation, dosimetry and radiation protection
SPECT and PET

Literature
Bildgebende Verfahren in der Medizin, Olaf Dössel, Springer Verlag

Remarks
Current information can be found on the ITIV (http://www.ibt.kit.edu/) webpage and within the eStudium-teachingplatform (www.estudium.org).

Course: Medical Imaging Techniques II [23262]

Coordinators: O. Dössel, O. Dössel
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	de

Learning Control / Examinations
The assessment consists of a written exam (approx. 120 minutes) according to sec. 4 subsec. 2 no. 1 study and examination regulations.

Conditions
None.

Learning Outcomes

Content

Course: Bioelectric Signals [23264]

Coordinators: G. Seemann, G. Seemann
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	de

Learning Control / Examinations
The assessment consists of an oral exam (approx. 20 minutes) according to sec. 4 subsec. 2 no. 2 study and examination regulations.

Conditions
None.

Learning Outcomes

Content

Course: Biomechanics: design in nature and inspired by nature [2181708]

Coordinators: C. Mattheck
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
Colloquium, ungraded.

Conditions
The number of participants is limited. Prior registration through ILIAS is necessary, In case of too many registrations, a selection (in accordance with SPO) will take place.
Before the registration in SP 26 (ME) or SP 01 (MSMT) the participation at the seminar must be confirmed.

Learning Outcomes
The students know and understand mechanical optimization schemes which are realized in nature. The students can analyze the derived thinking tools and can apply them for simple technical cases.

Content
* mechanics and growth laws of trees
* failure criteria and safety factors
* computer simulation of adaptive growth
* notches and damage case studies
* optimization inspired by nature
* structural shape optimization without computers
* universal shapes of nature
* fibre reinforces materials
* failure of trees, hillsides, dikes, walls and pipes

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

Coordinators: A. Guber
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach]

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

Learning Control / Examinations
The examination is in the form of a written examination (90 min.) (according to §4(2), 1 SPO).

Conditions
None.

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

Content
Introduction into various microtechnical manufacturing methods: LIGA, Micro milling, Silicon Micromachining, Laser Microstructuring, µEDM, Metal-Etching
Biomaterials, Sterilisation, Implants.
Examples of use in the life science sector: basic micro fluidic strucutures: micro channels, micro filters, micromixers, micropumps, microvalves, Micro and nanotiter plates, Microanalysis systems (µTAS),
Lab-on-chip applications.

Media
Lecture script

Literature
Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005
M. Madou
Fundamentals of Microfabrication
Taylor & Francis Ltd.; Auflage: 3. Auflage. 2011

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

Coordinators: A. Guber
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
Oral examination

Conditions
None.

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

Content
Examples of use in Life-Sciences and biomedicine: Microfluidic Systems:
LabCD, Digital Micro Fluidics
Microarrys
Tissue Engineering
Cell Chip Systems
Drug Delivery Systems
Microsystem Technology for Anesthesia, Intensive Care and Infusion
Analysis Systems of Person´s Breath
Neurobionics and Neuroprosthesis
Nano Surgery

Media
Lecture script

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

Buess, G.: Operationslehre in der endoskopischen Chirurgie, Band I und II;
Springer-Verlag, 1994
M. Madou
Fundamentals of Microfabrication (2011)

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

Coordinators: A. Guber
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Learning Outcomes
The lecture will address selected biomedical applications, as the increasing use of microstructures and microsystems in Life-Sciences und in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

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

Media
Lecture script

Literature
Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005
Buess, G.: Operationslehre in der endoskopischen Chirurgie, Band I und II;
Springer-Verlag, 1994
M. Madou
Fundamentals of Microfabrication (2011)

Course: Bionics for Engineers and Natural Scientists [2142140]

Coordinators: H. Hölscher
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
The successfull attandence of the lecture is controlled by a 90 minutes written examination outside of term-time once per semester.

Conditions
none

Learning Outcomes

Content

Literature
Werner Nachtigall: Bionik – Grundlagen und Beispiele für Ingenieure und Naturwissenschaftler. Springer-Verlag Berlin (2002), 2. Aufl.
Weitere Originalliteratur wird über ILIAS zur Verfügung gestellt.

Course: Bionic Inspired Reinforced Composites [2126811]

Coordinators: D. Koch
Part of the modules: SP 43: Technical Ceramics and Powder Materials (p. 449)[SP_43_mach]

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

Learning Control / Examinations
The assessment consists of an oral exam (20-30 min) taking place at the agreed date. The re-examination is offered upon agreement.

Conditions
none

Recommendations
Knowledge of basic material science is assumed.

Learning Outcomes
The students know the basics of the bionic based processing and design of composites. They know the bionic principles and knwo how to manufacture composites according to biaonic approach. They know manufacturing methods and components and apllication of such bioinspired composites. They have detailed knowledge of natural fiber reinforced composites.

Content
Bionic principles are defined and explained. Resulting composites from bionic approach are presented and manufacturing methods are shown. Potential and limit of bionic principle are discussed. Sustainability aspects concerning processing and use of bionic basded composites are taught. Examples show development and application of these composites.

Media
Slides for the lecture: available under http://ilias.studium.kit.edu

Literature

- A. von Gleich, C. Pade, U. Petschow, E. Pissarskoi,Bionik, Aktuelle Trends und zukünftige Poteniale.ISBN 978-3-932092-86-2, 2007.
- J. Müssig,Industrial Applications of Natural Fibres: Structure, Properties and Technical ApplicationsISBN: 978-0-470-69508-1, 2010, Wiley
- W. Nachtigall,Bionik: Grundlagen und Beispiele für Ingenieure und NaturwissenschaftlerISBN 978-3-642-62399-8, 2013, Springer

Course: BUS-Controls [2114092]

Coordinators: M. Geimer
Part of the modules: SP 34: Mobile Machines (p. 441)[SP_34_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 31: Mechatronics (p. 435)[SP_31_mach]

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

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.
The prerequisite for participation in the examination is the preparation of a report.

Conditions
None.

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

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

After the practical oriented lessons the students will be able to visualize the communication structure of different applications, design basic systems and evaluate the complexity of programming of the complete system.
Hereunto the students program in the practical orientated lessons IFM-controllers using the programming environment CoDeSys.

Content

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

Literature
Elective literature:

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

Remarks
The number of participants is limited. A registration is mandatory, the details are announced on the webpages of the *Institute of Vehicle System Technology | Institute of Mobile Machines*. In case of too many interested students a subset will be selected based on pre-qualification.

Course: Business Plan for Founders [2545009]

Coordinators: O. Terzidis
Part of the modules: SP 59: Innovation and Entrepreneurship (p. 464)[SP_59_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter / Summer Term	en

Learning Control / Examinations

Conditions

None.

Learning Outcomes

Content

Course: CAD-NX training course [2123357]

Coordinators: J. Ovtcharova
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

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

Learning Control / Examinations
Practical examination, duration: 60 min.

Conditions
None

Recommendations
Dealing with technical drawings is required.

Learning Outcomes
Students are able to:

- create their own 3D geometric models in the CAD system NX and generate drawings due to the created geometry
- carry out FE-studies and kinematic simulations using the integrated CAE tools
- use advanced, knowledge-based functionalities of NX to automate the creation of geometry and thus to ensure the reusability of the models.

Content
The participant will learn the following knowledge:

- Overview of the functional range
- Introduction to the work environment of NX
- Basics of 3D-CAD modelling
- Feature-based modelling
- Freeform modelling
- Generation of technical drawings
- Assembly modelling
- Finite element method (FEM) and multi-body simulation (MBS) with NX

Literature
Practical course skript

Remarks
For the practical course compulsory attendance exists.

Course: CAE-Workshop [2147175]

Coordinators: A. Albers, Assistenten
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach], SP 04: Automation Technology (p. 409)[SP_04_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 10: Engineering Design (p. 412)[SP_10_mach], SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

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

Learning Control / Examinations
Written-practical exam, duration 60 min

Conditions
compulsory attendance

Recommendations
We suggest this Workshop after 2 years of classes.

Learning Outcomes
The students are able to ...

- name the purposes and limits of numerical simulation and optimization of the virtual product development.
- solve simple realistic tasks in the field of finite element analysis and structure optimization with industrial common software.
- evaluate and to question the results of a simulation.
- identify and improve the mistakes of a simulation or optimization.

Content

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

Literature
The workshop script will be allocated at Ilias.

Course: CATIA advanced [2123380]

Coordinators: J. Ovtcharova
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

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

Learning Control / Examinations
assessment of another type

Conditions
None

Recommendations
Very good knowledge of Machine Design and an excellently passed CAD practical course CATIA at the IMI are required.

Learning Outcomes
At the workshop, a complete CAD model of a transmission is developed.
The design problem is worked out in small groups. Using a basic sketch the participants have to design partial solutions independently, test and then integrate them into the overall solution. The advanced capabilities of CATIA are dealt with. The design process should be simulated from idea to finished model.
The focus is on independent solution finding, teamwork, functional performance, production and design.

Content

- Use of advanced CAD techniques and CATIA functionalities
- Management of data using the PLM system SmarTeam
- Design engineering with CAD
- Integration of partial solutions into the overall solution
- Ensuring the reusability of CAD models through parameterization and cataloging
- Validation, strength tests (FEM analysis)
- Kinematic simulation with the digital mockup (DMU Kinematics)
- Production with integrated CAM tool
- Animations
- Presentation of results at the end of the semester

Remarks
For the workshop compulsory attendance exists.

Course: CFD for Power Engineering [2130910]

Coordinators: I. Otic
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach], SP 21: Nuclear Energy (p. 422)[SP_21_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach]

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

Learning Control / Examinations
Oral exam, length: 30 minutes

Conditions
None.

Learning Outcomes
After completing the course students are able:

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

Content
The course is aimed of giving the fundamental of Computational Fluid Dynamics (CFD) for energy technologies. Starting from the basic physical phenomena equations an overview on computational methods and turbulence modeling is given.
The course consists of both, a theoretical and a numerical component. The former will deal with the derivations and properties of the methods and models for CFD. The numerical part will make use of open source CFD computer program OpenFOAM to give a “hands on” insight into the simulation of turbulent flows. After completing the course you should be able to establish a connection between theory and CFD modeling and simulation for energy applications.

Course: CFD-Lab using Open Foam [2169459]

Coordinators: R. Koch
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations

- Successful solution of problems

Conditions
None.

Recommendations

- Basic knowledge in
- Fluid Dynamics
- Course on numerical fluid mechanics
- LINUX

Learning Outcomes
The students are able to:

- use OpenFOAM
- generate simple grids or import grids into OpenFOAM
- choose and define appropriate boundary conditions
- estimate numerical errors and asses them
- judge turbulence models and select an appropriate model
- simulate 2-phase flows using suitable models

Content

- Introduction to using Open Foam
- Grid generation
- Boundary conditions
- Numerical errors
- Discretization schemes
- Turbulence models
- Two phase flow - spray
- Two Phase flow - Volume of Fluid method

Media

- A CD containing the course material will be handed out to the students

Literature

- Documentation of Open Foam
- www.open foam.com/docs

Remarks

- Number of participants is limited
- Priority for students of the lecture “Numerische Simulation reagierender Zweiphasenströmungen” (Vorl.-Nr. 2169458)

Course: Coal fired power plants [2169461]

Coordinators: T. Schulenberg
Part of the modules: SP 23: Power Plant Technology (p. 424)[SP_23_mach]

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

Learning Control / Examinations
Oral examination
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Knowledge in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in power plant engineering. The participants can name the most important components of coal fired power plants and describe their function. They can design or modify coal fired power plants independently and creatively. They have acquired a broad knowledge of this power plant technology, including specific knowledge of combustion systems, of boiler design and of flue gas cleaning systems. On this basis, they can describe and analyze the specific behavior of the power plant components as well as the entire power plant in the grid. Participants in the lecture have a trained analytical thinking and judgment in power plant design.

Content
The lecture presents the technology of coal fired power plants, which are conventional steam turbine plants as well as advanced combined cycle power plants with integrated coal gasification. It includes combustion systems, steam generators, a short overview over steam turbine technologies, the cooling system and the water supply system as well as the off gas treatment. Coal gasification will be explained with fixed bed, fluidized bed and entrained flow gasifiers. The integrated coal gasification combined cycle includes also the raw gas purification system. In addition, a visit to a coal fired power plant will be offered.

Media
power point presentation for download from the ILIAS server

Literature
Lecture notes (Vorlesungsskript) for download from the ILIAS Server
Everett B. Woodruff, Herbert B. Lammers, Thomas F. Lammers, Steam Plant Operation, 9th Edition, McGraw Hill, New York 2012

Course: Computational Homogenization on Digital Image Data [2161123]

Coordinators: M. Schneider
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	2	Winter term	en

Learning Control / Examinations
Oral Exam

Conditions
none

Recommendations
Contents of “Advanced methods in strength of materials” or “Mathematical Methods in Strength of Materials”
This lecture is intended for Msc students.

Learning Outcomes
The students can
* explain the theory of homogenization for linear elastic solids
* assess the advantages/disadvantages of different compututional homogenization schemes
* program Lippmann Schwinger solvers
* know extensions for non-linear and time-dependent material laws

Content
* basic equations for computing effective elastic material properties
* Moulinec-Suquet’s FFT-based computational homogenization method
* schemes for treating highly contrasted/porous/defected media
* treating non-linear and time dependent mechanical proplems

Literature
Milton, G. W.: The Theory of Composites. Springer, New York, 2002.

Course: Computational Intelligence [2105016]

Coordinators: R. Mikut, W. Jakob, M. Reischl
Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach]

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

Learning Control / Examinations
Oral examination or written examination (for more than 40 participants),
Duration: 30min (oral) or 60 min (written)
Auxilary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students are able to apply the fundamental methods of computational intelligence (fuzzy logic, artificial neural networks, evolutionary algorithms) efficiently. They know the basic mathematical foundations and are able to transfer these methods to practical applications.

Content

- Terms and definitions Computational Intelligence, application fields and examples
- Fuzzy logic: fuzzy sets; fuzzification and membership functions; inference: T-norms and -conorms, operators, aggregation, activation, accumulation; defuzzification methods, structures for fuzzy control
- Artificial Neural Nets: biology of neurons, Multi-Layer-Perceptrons, Radial-Basis-Function nets, Kohonen maps, training strategies (Backpropagation, Levenberg-Marquardt)
- Evolutionary Algorithms: Basic algorithm, Genetic Algorithms and Evolution Strategies, Evolutionary Algorithm GLEAM, integration of local search strategies, memetic algorithms, application examples

Literature
Lecture notes (ILIAS)
Kiendl, H.: Fuzzy Control. Methodenorientiert. Oldenbourg-Verlag, München, 1997
S. Haykin: Neural Networks: A Comprehensive Foundation. Prentice Hall, 1999
Kroll, A. Computational Intelligence: Eine Einführung in Probleme, Methoden und technische Anwendungen Oldenbourg Verlag, 2013
Blume, C, Jakob, W: GLEAM - General Learning Evolutionary Algorithm and Method: ein Evolutionärer Algorithmus und seine Anwendungen. KIT Scientific Publishing, 2009 (PDF frei im Internet)
H.-P. Schwefel: Evolution and Optimum Seeking. New York: John Wiley, 1995
Mikut, R.: Data Mining in der Medizin und Medizintechnik. Universitätsverlag Karlsruhe; 2008 (PDF frei im Internet)

Course: Data Analytics for Engineers [2106014]

Coordinators: R. Mikut, M. Reischl, J. Stegmaier

Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach]

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

Learning Control / Examinations
Oral examination or written examination (for more than 40 participants),
Duration: 30min (oral) or 60 min (written)
Auxilary means: none

Conditions
None.

Recommendations
None.

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

Content

- Introduction and motivation
- Terms and definitions (types of multidimensional features - time series and images, problem classes)
- Scenario: Problem formulation, feature extraction, evaluation, selection and transformation, distance measures, Bayes classifiers, Support-Vector-Machines, decision trees, clustering, regression, validation
- Biweekly computer exercises (Software practice with SciXMiner): Data import, benchmark datasets, control of hand prostheses, energy prediction
- 2 hours per week lectures, 1 hour per week computer training

Literature
Lecture notes (ILIAS)
Mikut, R.: Data Mining in der Medizin und Medizintechnik. Universitätsverlag Karlsruhe. 2008 (free PDF in the Internet)
Backhaus, K.; Erichson, B.; Plinke, W.; Weiber, R.: Multivariate Analysemethoden: Eine anwendungsorientierte Einführung. Berlin u.a.: Springer. 2000
Burges, C.: A Tutorial on Support Vector Machines for Pattern Recognition. Knowledge Discovery and Data Mining 2(2) (1998), S. 121–167
Tatsuoka, M. M.: Multivariate Analysis. Macmillan. 1988
Mikut, R.; Bartschat, A.; Doneit, W.; Ordiano, J. Á. G.; Schott, B.; Stegmaier, J.; Waczowicz, S. & Reischl, M.: The MATLAB Toolbox SciXMiner: User's Manual and Programmer's Guide. arXiv:1704.03298, 2017

Course: A holistic approach to power plant management [2189404]

Coordinators: M. Seidl, R. Stieglitz
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach]

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

Learning Control / Examinations
oral

Conditions
none

Learning Outcomes
Students understand the many aspects of power plant operation: the structure of the energy and commodity markets, the regulatory boundary conditions, the energy trading instruments, the principles of fleet management and the requirements of power plant maintenance.
Furthermore, students can develop on their own a suitable strategy for the management of a power plant fleet.

Content
Industrial scale power plants are significant investments and their safe and economical operation requires careful examination of risk and uncertainty. Risk factors are, for example, technology, energy and commodity markets, regulatory boundary conditions and socioeconomic trends. They all require a disciplined fleet management to maximize asset value.
Risk and uncertainty factors are explained in depth as are the two fundamental vehicles for risk modelling: stochastic processes for random patterns and machine learning for repetitive patterns. They are combined to determine the optimal policy for decision making in the day-to-day management of power plants.

Literature
G. Balzer, C. Schorn, Asset Management für Infrastrukturanlagen - Energie und Wasser, VDI
R. Weron, Modeling and Forecasting Electricity Loads and Prices: A Statistical Approach, Wiley
D. Edwards, Energy Trading and Investing: Trading, Risk Management and Structuring Deals in the Energy Market, McGraw-Hill

Course: Design Thinking [2545011]

Coordinators: O. Terzidis, Dr. Kneisel, Dr. H. Haller, P. Nitschke
Part of the modules: SP 59: Innovation and Entrepreneurship (p. 464)[SP_59_mach]

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

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

Course: NMR micro probe hardware conception and construction [2142551]

Coordinators: J. Korvink, M. Jouda
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
Successful participation.

Conditions
None.

Learning Outcomes
Participants will learn how to design, build, and operate their own NMR or MRI probehead.

Content
The practicum will start with a series of lectures on the fundamental principles of NMR and probehead construction. Thereafter, basic concepts will be tested at the workbench, for example:

- Measuring RF impedance and S-parameters.
- Tuning and Matching.
- Design principles

Thereafter, each participant will produce an **open hardware** project probehead, suitable for use in a commercial MRI machine. The probehead is of modular design, so that participants can then construct their own custom detection coil. Finally, the whole system is tested inside a commercial MRI small animal machine.
A short manual is provided.

Literature
Chen, C. N. & Hoult, D.
BIOMEDICAL MAGNETIC RESONANCE TECHNOLOGY.
Adam Hilger, 1989
Joel Mispelter, Mihaela Lupu, Andre Briguet
NMR Probeheads for Biophysical and Biomedical Experiments: Theoretical Principles and Practical Guidelines: Theoretical Principles and Practical Guidelines
Imperial College Press, 2015

Course: Railways in the Transportation Market [2114914]

Coordinators: P. Gratzfeld
Part of the modules: SP 50: Rail System Technology (p. 456)[SP_50_mach]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes
The students realise the entrepreneurial perspective of transportation companies and are able to follow their operational fields. They understand the regulative determinates and learn to assess the intra- and intermodal competitive position.

Content
The lecture communicates the entrepreneurial view on chances and challenges of railways in the transportation markets. Following items will be discussed:

- Introduction and basics
- Rail reform in Germany
- Overview of Deutsche Bahn
- Financing and Development of infrastructure
- Regulation of railways
- Intra- and intermodal competition
- Field of actions in transport policy
- Railways and environment
- Trends in the transportation market
- Future of Deutsche Bahn, program called "Zukunft Bahn"
- Digitalisation

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

Literature
none

Remarks
For the dates please see special announcement on the website www.bahnsystemtechnik.de

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

Coordinators: C. Günther
Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
oral
Duration: 30 minutes
no auxiliary means

Conditions
None.

Learning Outcomes
The students can apply the most important difference schemes for the numerical solution of steady and transient problems which are typical for thermal and fluid flow problems. They are able to discuss the most relevant properties of difference schemes such as consistency, stability and convergence. Furthermore, they can estimate the order of the numerical error and non-appearance of numerical oscillations.
The students get a basic knowledge of relevant numerical algorithms and the use of them in commercial and open fluid flow codes.

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

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

Course: Digital Control [2137309]

Coordinators: M. Knoop

Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

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

Conditions
Basic studies and preliminary examination; basic lectures in automatic control

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

Content
1. Introduction into digital control:
Motivation for digital implementation of controllers Structure of digital feedback control loops Sample and hold units
2. State space analysis and design:
Discretisation of continuous-time systems Discrete-time state space equations Stability - definition and criteria State feedback design by eigenvalue assignment PI state feedback controller Luenberger observer, separation theorem Systems with dead-time Deadbeat design
3. Analysis and design based on z-transform: z-transform - definition and theorems Control loop description in the z domain
Stability criteria Root locus controller design Transfer of continuous-time controllers into discrete-time controllers

Literature

- Lunze, J.: Regelungstechnik 2 - Mehrgrößensysteme, Digitale Regelung, 8. Auflage, Springer Verlag, Berlin Heidelberg 2014
- Unbehauen, H.: Regelungstechnik, Band 2: Zustandsregelungen, digitale und nichtlineare Regelsysteme. 8. Auflage, Vieweg Verlag, Braunschweig 2000
- Föllinger, O.: Lineare Abtastsysteme. 4. Auflage, R. Oldenbourg Verlag, München Wien 1990
- Ogata, K.: Discrete-Time Control Systems. 2nd edition, Prentice-Hall, Englewood Cliffs 1994
- Ackermann, J.: Abtastregelung, Band I, Analyse und Synthese. 3. Auflage, Springer Verlag, Berlin Heidelberg 1988

Course: Digitalization of Products, Services & Production [2122310]

Coordinators: B. Pätzold
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

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

Learning Control / Examinations

Conditions
None.

Learning Outcomes
- Students are able to describe the fundamental challenges and objectives of the progressive digitalization of products, service and production. In context of these challenges, students can name and explain the essential terms.
- Students can illustrate the key drivers and fundamental technologies behind the digitalization of products, services and processes.
- Students can describe the challenges of the ongoing digitalization and the corresponding changes in business processes and distinguish between them in regards to time and place. Furthermore, students are able to assign the IT-Architecture and systems to the corresponding process steps.
- Students can highlight the requirement for future information management in networks of product development and production institutions and can clarify how to validated and safeguard the corresponding IT processes.
- Students are able to analyze the challenges of digitalization and present potential solution approaches via self-created scenarios for future developments.

Content

- Digitalization of products, services and production in the context of Industry 4.0 .
- Key drivers for ongoing digitalization and their impact on future product development and manufacturing.
- Methods and procedures to design the according transformation process.
- Intensive group discussions of use-case scenarios using practical examples from the industry.

Course: Designing with numerical methods in product development [2161229]

Coordinators: E. Schnack
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach]

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

Learning Control / Examinations
Oral examination. Duration: 20 minutes.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students are able to describe in detail the different numerical methods for product development in mechanical engineering. They are aware of the fact that modern development of products in mechanical engineering generally involves a so-called multi-field approach. This means that knowledge of thermodynamics, fluid mechanics, solid-state mechanics, electronics/electrics, and magnetism is required. In addition, the students use the methods taking into account that problems in product development are not only stationary, but very often also unstationary, i.e. time-dependent. All these aspects are reflected by modern industry software.
The students can name and describe basic methods used in modern industry software. On this basis, students can name and describe the necessary steps of a design process with an industry software being used as an example and they can analyze influencing factors. Apart from the finite element method (FEM) and the boundary element method (BEM), they also consider structural optimization with its elements of topology and shape optimization. Structural optimization will gain importance in the future.
The lecture notes are made available via ILIAS.

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

Course: Designing with composites [2162255]

Coordinators: E. Schnack
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach]

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

Learning Control / Examinations
Oral examination. Duration: 20 minutes.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students understand and are able to describe the structure of laminated composite materials. They consider the nonlinear effects resulting from the absorption of humidity and temperature impacts. Moreover, they take into account the intrinsic stresses and strains resulting from production.
The students develop the equations required for description. They consider the transformation properties between a single-layer and a multi-layer coordinate system as well as the geometrically nonlinear behavior of the structures. On this basis, the students derive a universal lamination theory that also takes into account nonlinear effects. This is the basis for the future development of smart composites (via piezoelectric control) for new products (e.g. in aviation and automotive industries). In parallel, students are able to develop oscillation equations for composites which is the basis for any application in mechanical engineering.
The lecture notes are made available via ILIAS.

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

Course: Dynamics of the Automotive Drive Train [2163111]

Coordinators: A. Fidlin
Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], (p. 466)[SP_61_mach], (p. 465)[SP_60_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Powertrain Systems Technology A: Automotive Systems
Machine Dynamics
Vibration theory

Learning Outcomes

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

Content

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

Literature

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

Course: eEnergy: Markets, Services, Systems [2540464]

Coordinators: C. Weinhardt
Part of the modules: SP 59: Innovation and Entrepreneurship (p. 464)[SP_59_mach]

ECTS Credits	Hours per week	Term	Instruction language
4,5	2/1	Summer term	en

Learning Control / Examinations
The assessment consists of a written exam (60 min) (according to §4(2), 1 of the examination regulation). By successful completion of the exercises (according to §4(2), 3 of the examination regulation) a bonus can be obtained. If the grade of the written exam is at least 4.0 and at most 1.3, the bonus will improve it by one grade level (i.e. by 0.3 or 0.4). The bonus only applies to the first and second exam of the semester in which it was obtained.

Conditions
None.

Learning Outcomes
The student

- understands the tasks and basic structure of the energy economy, in particular concerning electricity markets,
- understands the change in the energy economy and the necessity for the development of a Smart Grid,
- knows the market mechanisms in the energy market and their role in coordination and allocation of electric energy,
- is able to describe the relation between OTC, spot and balancing energy markets,
- knows the regulation specifications for energy markets and can reflect them critically,
- is able to model smart grid mechanisms and to evaluate them by simulation based methods.

Content
Scope of the lecture *eEnergy: Markets, Services, Systems* is economics and information management in energy markets. Integration of the growing number of renewable energy sources imposes new challenges on energy markets and the power system. To improve coordination between supply and demand it is necessary to interlink centralized and decentralized generators as well as consumers by means of ICT. Current electricity networks are extended by intelligent IT components thus incorporating the “Smart Grid”. Existing market structures for electricity have to be adjusted for a successful implementation of demand side management and integration of an increasing number of renewable energy producers as well as electric vehicles. Apart from regulatory and economic concepts, methods for modeling and analysis of energy markets are introduced and explained during the course.
The lecture is structured as follows:

1. **Electricity Markets**
   Market Models, EEX (spot and futures market), OTC Trading, Market Coupling
2. **Regulation**
   Charges and Incentives, Network Congestion (Management)
3. **Demand Side Management**
   Smart Meters, Tariffs, Price Elasticity, Storage Systems, Electric Mobility
4. **Modeling and Analysis of Energy Markets**

Media

- PowerPoint
- E-learning platform ILIAS

Literature

- Erdmann G, Zweifel P. *Energieökonomik, Theorie und Anwendungen*. Berlin Heidelberg: Springer; 2007.
- Grimm V, Ockenfels A, Zoettl G. Strommarktdesign: Zur Ausgestaltung der Auktionsregeln an der EEX *. *Zeitschrift für Energiewirtschaft*. 2008:147-161.
- Stoft S. *Power System Economics: Designing Markets for Electricity*. IEEE; 2002.,
- Ströbele W, Pfaffenberger W, Heuterkes M. *Energiewirtschaft: Einführung in Theorie und Politik*. 2nd ed. München: Oldenbourg Verlag; 2010:349.

Remarks
The lecture has also been added in the IIP Module *Basics of Liberalised Energy Markets*.

Course: Introduction to the Finite Element Method [2162282]

Coordinators: T. Böhlke
Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 25: Lightweight Construction (p. 427)[SP_25_mach]

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

Learning Control / Examinations
depending on choice according to acutal version of study regulations
Additives as announced
Prerequisites are met by attestations during the associated lab course.

Conditions
None.

Recommendations
The contents of the lectures “Advanced methods in strength of materials” and “Mathematical methods in strength of materials” are a prerequisite.

Learning Outcomes
The students can

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

Content

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

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

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

Course: Introduction to Nuclear Energy [2189903]

Coordinators: X. Cheng
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 21: Nuclear Energy (p. 422)[SP_21_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach]

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

Learning Control / Examinations

Conditions
None.

Learning Outcomes
This lecture is dedicated to students of mechanical engineering and other engineering Bachelor or Master degree courses. Goal of the lecture is the fundamental knowledge of nuclear energy and nuclear reactors. After the lecture the students understand the principle of the usage of nuclear energy, the structure and operation of nuclear power plants and nuclear safety measures. Furthermore, the students are capable of giving technical assessment of the usage of nuclear energy with respect to its safety and sustainability.

Content

Course: Introduction to Theory of Materials [2182732]

Coordinators: M. Kamlah
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach]

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

Learning Control / Examinations
oral exam 30 minutes

Conditions
None.

Recommendations
Engineering Mechanics; Advanced Mathematics

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

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

Literature
[1] Peter Haupt: Continuum Mechanics and Theory of Materials, Springer
[2] Lecture Notes

Course: Introduction into Mechatronics [2105011]

Coordinators: M. Reischl, M. Lorch
Part of the modules: SP 40: Robotics (p. 445)[SP_40_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 04: Automation Technology (p. 409)[SP_04_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach]

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

Learning Control / Examinations
Written examination, 120 minutes

Conditions
none

Learning Outcomes
The student knows the specific challenges in interdisciplinary collaboration within the framework of mechatronics. He is able to explain the origin, necessity and methodic implementation of interdisciplinary collaboration, to name the main difficulties as well as the special features within the development of mechatronic products from the point of view of development methodics.
The student has fundamental knowledge of modeling mechanical, hydraulically and electrically sub-systems and about suitable optimization methods.
The student knows the difference in use of the term "system" in mechatronic and mechanical use.

Content

- Introduction
- Structure of mechatronic systems
- Sensors and actuators
- Measurement processing
- Modeling of mechatronic systems
- Control of mechatronic systems
- Information processing in mechatronics

Literature

- H. Czichos. Mechatronik. Grundlagen und Anwendungen technischer Systeme. Vieweg, 2006.
- O. Föllinger. Regelungstechnik: Einführung in die Methoden und ihre Anwendung. Hüthig, 1994.
- J. Hartung. Statistik: Lehr- und Handbuch der angewandten Statistik. Oldenbourg, 2009.
- R. Isermann. Mechatronische Systeme: Grundlagen. Springer,1999.
- W. Roddeck. Einführung in die Mechatronik. Teubner, 2012.

Course: Introduction into the multi-body dynamics [2162235]

Coordinators: W. Seemann
Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], (p. 466)[SP_61_mach]

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

Learning Control / Examinations
Written or oral exam.
Announcement 6 weeks prior to examination date.

Conditions
None.

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

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

Literature
Wittenburg, J.: Dynamics of Systems of Rigid Bodies, Teubner Verlag, 1977
Roberson, R. E., Schwertassek, R.: Dynamics of Multibody Systems, Springer-Verlag, 1988
de Jal'on, J. G., Bayo, E.: Kinematik and Dynamic Simulation of Multibody System.
Kane, T.: Dynamics of rigid bodies.

Course: Introduction to numerical fluid dynamics [2157444]

Coordinators: B. Pritz
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach]

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

Learning Control / Examinations
Certificate of participation

Conditions
None.

Recommendations
Knowledge in:

- Computational Methods in Fluid Mechanics
- Fluid Mechanics (german language)

Learning Outcomes
Students

- know the three components of CFD: mesh generation, calculation and evaluation.
- will be able to create simple geometries and generate mesh.
- can set up and carry out simulations.
- know the ways of evaluating the results and the possibilities of flow visualization.
- know how to analyze flow situations.

Content
In the lab, the components of the cycle of computational fluid dynamics are worked through. In the first instance moderately complicated geometries will be generated and meshed. After the configuration and running the calculation, the results are presented and evaluated in a visualization software. While in the first part of the course these steps are worked out under guidance, calculation cycles are carried out independently in the second part. The test cases are discussed in detail and allow to strengthen the affinity to the fluid dynamics.
Content:

1. Brief introduction into Linux
2. Mesh generation with ICEMCFD
3. Data visualisation and interpretation with Tecplot
4. Handling of the flow solver SPARC
5. Self-designed calculation: flat plate
6. Introduction to unsteady calculations: flow around a circular cylinder

Literature
Lecture notes/handout

Remarks
In winter term 2012/2013:
Course: Computational Methods in Fluid Mechanics (Exercise) [2157442]

Course: Introduction to Nonlinear Vibrations [2162247]

Coordinators: A. Fidlin
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach], (p. 465)[SP_60_mach]

ECTS Credits	Hours per week	Term	Instruction language
7	4	Winter term	de

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Vibration theory, mathematical methods of vibration theory, dynamic stability

Learning Outcomes
The students

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

Content

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

Literature

- Hagedorn P. Nichtlineare Schwingungen. Akademische Verlagsgesellschaft, 1978.
- Nayfeh A.H., Mook D.T. Nonlinear Oscillation. Wiley, 1979.
- Thomsen J.J. Vibration and Stability, Order and Chaos. McGraw-Hill, 1997.
- Fidlin A. Nonlinear Oscillations in Mechanical Engigeering. Springer, 2005.
- Bogoliubov N.N., Mitropolskii Y.A. Asymptotic Methods in the Theory of Nonlinear Oscillations. Gordon and Breach, 1961.
- Nayfeh A.H. Perturbation Methods. Wiley, 1973.
- Sanders J.A., Verhulst F. Averaging methods in nonlinear dynamical systems. Springer-Verlag, 1985.
- Blekhman I.I. Vibrational Mechanics. World Scientific, 2000.
- Moon F.C. Chaotic Vibrations – an Introduction for applied Scientists and Engineers. John Wiley & Sons, 1987.

Course: Electric Rail Vehicles [2114346]

Coordinators: P. Gratzfeld
Part of the modules: SP 50: Rail System Technology (p. 456)[SP_50_mach]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes
The students know the history of electric traction in railway transportation from the very beginning to modern vehicles with three-phase traction drives.
They know the basics of railway transportation, vehicle dynamics and wheel-rail-contact and can deduct the requirements for electric rail vehicles out of it.
They understand purpose, design and functionality of electric traction drives.
They learn about the different systems of traction power supply with its advantages and disadvantages.
They are informed about actual concepts and new developments in the field of electric railway vehicles.

Content
History of electric traction with railway vehicles, economic impact
Vehicle dynamics: running resistance, tractive effort diagram, running cycles
Wheel-rail-contact
Electric drives: traction motors, power conversion, drives for vehicles at dc and ac lines, dieselelectric vehicles, multi system vehicles, axle drives, transmission of tractive effort to the rails
Traction power supply: networks, substations, inductive power supply, energy management
Modern vehicle concepts for mass transit and main line

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

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

Course: Elements of Technical Logistics [2117096]

Coordinators: M. Mittwollen, G. Fischer
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

Learning Control / Examinations
after each lesson period; oral / written (if necessary)

Conditions
None.

Recommendations
previous / parallel visit of LV 21177095 “Grundlagen der Technischen Logistik”

Learning Outcomes
Students are able to:

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

Content
material flow systems and their (conveying) technical components
mechanical behaviour of conveyors;
structure and function of conveyor machines; elements of intralogistics (belt conveyor, racks, automatic guided vehicles, fan-in, bifurcation, and etc.)
sample applications and calculations in addition to the lectures inside practical lectures

Media
supplementary sheets,projector, blackboard

Literature
recommendations during lectures

Course: Elements of Technical Logistics - Project [2117097]

Coordinators: M. Mittwollen, G. Fischer
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

Learning Control / Examinations
Lesson: after each lesson period; oral / written (if necessary)
(counts two-thirds);
Project: presentation, marked (counts one third)

Conditions
None.

Recommendations
previous / parallel visit of LV 21177095 “Grundlagen der Technischen Logistik”

Learning Outcomes
Students are able to:

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

Content
mechanical behaviour of conveyors;
structure and function of conveyor machines; elements of intralogistics (belt conveyor, racks, automatic guided vehicles, fan-in, bifurcation, and etc.)
sample applications and calculations in addition to the lectures inside practical lectures
Self manufacturing of a project report to recesses the topic.

Media
supplementary sheets,projector, blackboard

Literature
recommendations during lectures

Course: Energy and Indoor Climate Concepts [1720970]

Coordinators: A. Wagner, wissenschaftl. Mitarbeiter
Part of the modules: SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach]

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

Learning Control / Examinations
Forming of the grades: 100 % oral examination
Proof of performance and examination: oral examination (30 minutes)
Form of examination: oral

Conditions
None.

Learning Outcomes
The objective of the course is – based on the fundamental lectures in the first 4 semesters of the Bachelor – to communicate actual findings and technologies in the field of energy effiency in buildings. The students should understand physical and technical interrelations and recognize that a high "building performance" is the result of an integrated building and energy concept. They should be able to judge which technologies lead to energy-efficient solutions in a certain building context.

Content
The contents of the course *Energy and Indoor Climate Concepts* includes innovative measures for thermal protection of buildings, passive solar energy use and ventilation technology. With focus on non-residential buildings also concepts and technologies for passive cooling and for (day)lighting are presented. New strategies for the renewable energy supply of heat and electricity point out the way towards climate-neutral energy concepts.

Remarks

- Obligatory excursion
- Lecture slides as pdf, recommendations for further reading

Course: Energy demand of buildings – fundamentals and applications, with building simulation exercises [2158203]

Coordinators: F. Schmidt
Part of the modules: SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	de

Learning Control / Examinations

- Project work as prerequisite for oral exam (solution of assigned building simulation task, including presentation in front of class)
- Mode of examination: oral (30 min.)

Conditions
Conditions: Cannot be combined with the following courses:

- Building Simulation [2157109]
- Energy and indoor climate concepts for high performance buildings [1720997]

Learning Outcomes
The students know the influencing factors on the energy demand of buildings. They know the requirements and prerequisites for low energy and passive houses. They are familiar with methods for setting up energy balances for buildings and the relevant technical building equipment. Students are able to judge under which circumstances zero-energy or plus-energy buildings (with respect to the annual primary energy balance) are attainable. They know the requirements and criteria for occupants' comfort in buildings and they are able to estimate the influence of different renovation and retrofit measures on the energy demand and occupants' comfort. They know use cases and limits of different heat transfer systems for heating and cooling of rooms and are familiar with low exergy concepts for building energy systems.
Through integrated computer exercises, students learn to set up energy models of buildings, perform simulations and sensitivity analysis using these models and to evaluate and present their results.

Content

- Selected topics of building physics regarding energy demand of buildings for heating and cooling
- Occupants' comfort in buildings
- Ventilation demand and ventilation concepts
- The passive house concept
- Passive use of solar energy in buildings
- Passive systems / concepts for cooling of buildings
- Exergetic evaluation of building systems
- Heat transfer systems to rooms for heating and cooling, "low-ex" systems
- Numerical methods in building simulation
- Generation of load series, simulation of technical building equipment

Literature
same as in German, no English version of book by Pehnt (ed.) available)

Course: Energy efficient intralogistic systems [2117500]

Coordinators: M. Braun, F. Schönung
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach]

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

Learning Control / Examinations
oral,30 min, examination dates after the end of each lesson period

Conditions
None.

Recommendations
None.

Learning Outcomes
Students are able to:

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

Content
The main focuses of the course are:

- green supply chain
- processes in Intralogistic systems
- evaluation of energy consumption of conveyors
- modeling of conveying systems
- methods for energy savings
- approaches for energy efficiency increasing of continuous and discontinuous conveyors
- dimensioning energy efficient drives
- new approaches for resource efcient material handling equipment and systems
  - benchmarking of energy efficiency of various intralogistics systems

Media
presentations, black board

Literature
None.

Remarks

- The content of the course “Fundamentals of technical logistics” should be known
- During the course there will be several external specific presentations of energy related topics of intralogistics companies
- Visit the IFL homepage of the course for the course dates and/or possible limitations of course participation

Course: Energy Storage and Network Integration [2189487]

Coordinators: R. Stieglitz, W. Jaeger, Jäger, Noe
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach]

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

Learning Control / Examinations
oral: (can be given in english)
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
The courses 2189487 Energiespeicher und Netzintegration and 23687 Energy Storage and Network Integration can not be combined.

Recommendations
Fundamentals in material sciences, fluid dynamics and chemistry
Fundamental Knowledge of energy technology, thermodynamics, physics and electrical engineering

Learning Outcomes
Students understand the different types of energy storage in a physical sense. They are enabled to evaluate their capacity and limitiations and how physical conditions translate into technical designs. Based on these fundamentals they are taught to apply the gained knowledge for the selection and principal dimensioning of relevant energy storage tasks.
Furthermore, students can reflect the state-of-the-art of most important energy storage types, their fundamental characterisitics and viability at given boundary conditions and they are enabled to elaborate and apply basic integration issues dependent on the grid structure for the different network types.

Content
The lecture provides an overview of the different storage types and their fundamental integration into the power supply grid.
Thereby, within the scope of this lecture, the necessity and the motivation for converting and storing energy will be given. Starting from the definition of fundamental terms different physical and chemical storage types along with their theoretical and practical basis are described. In particular, the decoupling of energy production and energy consumption, and the provision of different energy scales (time, power, density) will be discussed. Furthermore, the challenge of energy transport and re-integration into the different grid types is considered.
Main Contents

1. Motivation for the need of energy storage in energy systems
   (a) National and international situation
   (b) Storage motivation
2. Terms and definitions
   (a) Different energy types
   (b) Definitions energy content
   (c) Definitions energy- and power density
3. Thermal energy storage
   (a) Classification
   (b) Sensitive heat storage
   (c) Latent heat storage
   (d) Reaction heat storage

4. Mechanical energy storage
   (a) Flywheels
   (b) Compressed air
   (c) Pumpes storage systems
5. Electrodynamic energy storage
   (a) Main principles
   (b) Capazitive and inductive storage
6. Electrochemical energy storage
   (a) Working principles
   (b) Batteries
   (c) Fuel Cells
7. Network types
   (a) Integrated networks
   (b) Supply security
8. Electric Power Systems
   (a) Storage tasks
   (b) Storage íntegration
   (c) Planning reserves
9. Heat networks
   (a) Feed in and heat distribution
   (b) Planning supply
10. Transport of chemical energy carriers and networks
    (a) Capacity and safety
    (b) Options for conversion

The lecturer reserves the right to alter the contents of the course without prior notification.

Media
Päsentation (transparencies exclusivley in english) complemented by print-outs, exercise sheets

Literature
Within each subblock an adequate selection of literature is given. Additionally the students get the lecuture materials in printed and electronic version.

Course: Energy Systems I: Renewable Energy [2129901]

Coordinators: R. Dagan
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach], SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

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

Learning Control / Examinations
Oral examination

Conditions
None.

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

Content
The course deals with fundamental aspects of renewable energies.

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

Course: Energy systems II: Reactor Physics [2130929]

Coordinators: A. Badea
Part of the modules: SP 21: Nuclear Energy (p. 422)[SP_21_mach]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Learning Outcomes
The goal is to get experienced with nuclear, cooling and control engineering calculation methods for the design of nuclear power plants with nuclear fission reactors and with the safety standards in the nuclear industry.

Content
nuclear fission & fusion,

radioactive decay, neutron excess, fission, fast and
thermal neutrons, fissile and fertile nuclei,

neutron flux, cross section, reaction rate, mean free path,
chain reaction, critical size, moderation,

reactor dynamics,

transport- and diffusion-equation for the neutron flux distribution,
power distributions in reactor,

one-group and two-group theories,

light-water reactors,

reactor safety,

design of nuclear reactors,

breeding processes,

nuclear power systems of generation IV

Course: Energy Conversion and Increased Efficiency in Internal Combustion Engines [2133121]

Coordinators: T. Koch, H. Kubach
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

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

Learning Control / Examinations
oral exam, 25 minutes, no auxillary means

Conditions
None.

Recommendations
especially reasonable in combination with lecture “Combustion Engines I”

Learning Outcomes
The students can name all important influences on the combustion process. They can analyse and evaluate the engine process considering efficiency, emissions and potential.

Content
1. Introduction
2. Thermodynamics of combustion engines
3. Fundamentals
4. gas exchange
5. Flow field
6. Wall heat losses
7. Combustion in gasoline engines
8. APR und DVA
9. Combustion in Diesel engines
10. Emissions
11. Waste heat recovery
12. Measures to increase efficiency

Media
Slides, Script

Course: Entrepreneurship [2545001]

Coordinators: O. Terzidis
Part of the modules: SP 59: Innovation and Entrepreneurship (p. 464)[SP_59_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter / Summer Term	en

Learning Control / Examinations
The assessment consists of a written exam (60 minutes) (following §4(2), 1 of the examination regulation).

Conditions
None.

Learning Outcomes
Students are generally introduced to the topic of entrepreneurship. After successful completion of the lecture they should have an overview of the sub-areas of entrepreneurship and have to be able to understand basic concepts of entrepreneurship.

Content
This lecture, as an obligatory part of the module “Entrepreneurship”, introduces basic concepts of entrepreneurship. It approaches the individual steps of dynamic corporate development. The focus here is the introduction to methods for generating innovative business ideas, the translation of patents into business concepts and general principles of financial planning.
Other topics are the design and use of service-oriented information systems for founders, technology management, business model generation and lean startup methods for the implementation of business ideas in the way of controlled experiments in the market.

In addition to the lectures the KIT Entrepreneurship Talks, where successful entrepreneurs share their experiences from the early stages of their companies, will be given. Dates and times will be announced in time on the EnTechnon website.

More details: http://etm.entechnon.kit.edu/211.php

Course: Design Project Machine Tools and Industrial Handling [2149903]

Coordinators: J. Fleischer
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
The Design Project Machine Tools an Industrial Handling can only be combined with the lecture Machine Tools and Industrial Handling (Lecture-No. 2149902). The number of students is limited to five.

Recommendations
None

Learning Outcomes
The students ...

- can develop ideas for technical solutions in a team and evaluate their feasibility according to technical and economic criteria,
- are capable of selecting the essential components and modules and carrying out the necessary calculations,
- can use FEM simulations to predict and evaluate the static and dynamic behavior of an assembly,
- are able to present, plan and assess their own work and decision-making processes.

Content
The Design Project Machine Tools and Industrial Handling offers a practical insight into the development of machine tools. A student team works on a current and concrete problem in the field of machine tools. This problem is introduced into the project by an industrial partner.
First, the problem is to be translated into work packages. Following the project plan, ideas and concepts are to be developed as to how the problem is to be solved. Based on the concepts, the validation is carried out using analytical and numerical methods. The results of the project will be presented in a final meeting. The project is carried out by the students under the guidance of scientific staff and in cooperation with the industrial partner. The development project offers students

- the unique opportunity to put the contents of the accompanying lecture into practice in an interdisciplinary and creative context,
- to gain insights into a wide range of development activities relevant for their future careers,
- cooperation with an attractive industrial partner,
- work in a team with other students with competent support from scientific staff,
- first practical experience in project management.

Media
SharePoint, Siemens NX 9.0

Literature
None

Course: Fatigue of Welded Components and Structures [2181731]

Coordinators: M. Farajian, P. Gumbsch,
Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
Exercise sheets are handed out regularly.
oral examination (ca. 30 min)

no tools or reference materials

Conditions
None.

Recommendations
preliminary knowlegde materials science and mechanics

Learning Outcomes
The student can

- describe the influence of welding induced notches, defects and residual stresses on component behavior
- explain the basics of numerical and experimental methods for the evaluation of statically or cyclically loaded welds explain and can apply them
- derive measures in order to increase the lifetime of structures with welded joints under cyclical load

Content
The lecture gives an introduction to the following topics:

- weld quality
- typical damages of welded joints
- evaluation of notches, defects and residual stresses
- strength concepts: nominal, structural and notch stress concepts, fracture mechanics
- life cycle analysis
- post-treatment methods for an extented lifetime
- maintenance, reconditioning and repair

Media
Black board and slides (beamer).

Literature

1. D. Radaj, C.M. Sonsino and W. Fricke, Fatigue assessment of welded joints by local approaches, Second edition.Woodhead Publishing, Cambridge 2006.
2. FKM-Richtlinie, Bruchmechanischer Festigkeitsnachweis, Forschungskuratorium Maschinenbau, VDMA Verlag, 2009

Course: Organ support systems [2106008]

Coordinators: C. Pylatiuk
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach]

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

Learning Control / Examinations
written examination

Conditions
None.

Recommendations
Fundamentals of medicine

Learning Outcomes
The course deals with the function and clinical application of organ support systems, artificial organs and its components.
Historical developments are displayed as well as the limitations of current systems and perspectives for future systems Finally, the limits and possibilities of transplantation and tissue engineering are given.

Content

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

Media
The slides for each lecture can be downloaded via ILIAS.

Literature

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

Course: Experimental Dynamics [2162225]

Coordinators: A. Fidlin
Part of the modules: (p. 465)[SP_60_mach], (p. 466)[SP_61_mach]

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

Learning Control / Examinations
Oral examination

Conditions
The courses [2161241] and [2162225] can not be combined.

Recommendations
Vibration theory, mathematical methods of vibration theory, dynamic stability, nonlinear vibrations

Learning Outcomes

- To learn the basic principles for dynamic measurements
- To learn the basics of the experimental model validation
- To get the first experience in the digital data analysis
- To learn the limits of the minimal models
- To be able to perform simple measurements

Content

1. Introduction
2. Measurement principles
3. Sensors as coopled multi-physical systems
4. Digital signal processing, measurements in frequency domain
5. Forced non-linear vibrations
6. Stability problems (Mathieu oscillator, friction induces vibrations)
7. Elementary rotor dynamics
8. Modal analysis

Remarks
The lectures will be accompanied by the laboratory experiments.

Course: Experimental Fluid Mechanics [2154446]

Coordinators: J. Kriegseis
Part of the modules: SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
None.

Recommendations
Fundamental Knowledge about Fluid Mechanics

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

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

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

Media
Slides, chalk board, overhead

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

Course: Metallographic Lab Class [2175590]

Coordinators: U. Hauf
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
Colloquium for every experiment, about 60 minutes, protocol

Conditions
Materials Science I/II

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

Content
Light microscope in metallography
metallographic sections of metallic materials
Investigation of the microstructure of unalloyed steels and cast iron
Microstructure development of steels with accelerated cooling from the austenite area
Investigation of microstructures of alloyed steels
Investigation of failures quantitative microstructural analysis
Microstructural investigation of technically relevant non-ferrous metals
Application of Scanning electron microscope

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

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

Literature List will be handed out with each experiment

Course: Welding Lab Course, in groupes [2173560]

Coordinators: J. Hoffmeister
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
Certificate to be issued after evaluation of the lab class report

Conditions
Certtificate of attendance for Welding technique (The participation in the course Welding Technology I/II is assumed.).

Learning Outcomes
The students are capable to name a survey of current welding processes and their suitability for joining different metals. The students can evaluate the advantages and disadvantages of the individual procedures. The students have weld with different welding processes.

Content
Gas welding of steels with different weld geometries

Gas welding of cast iron, nonferrous metals

Brazing of aluminum

Electric arc welding with different weld geometries

Gas welding according to the TIG, MIG and MAG procedures

Literature
distributed during the lab attendance

Remarks
The lab takes place at the beginning of the winter semester break once a year. The registration is possible during the lecture period in the secretariat of the Institute of Applied Materials (IAM – WK). The lab is carried out in the Handwerkskammer Karlsruhe.
You need sturdy shoes and long clothes!

Course: Experimental techniques in thermo- and fluid-dynamics [2190920]

Coordinators: X. Cheng
Part of the modules: SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

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

Learning Control / Examinations
oral exam, duration 20 min

Conditions
none

Learning Outcomes
This lecture is for students of Mechanical Engineering and other Engineering Departments in the Bachelor program as well as in Master program. It is devoted to the fundamental processes and tasks of the experimental techniques in thermo- and fluid-dynamics. The lecture deals with the design and analysis of experimental facilities. Measurement techniques and analysis of experimental data belong also to the key issues of the lecture. This lecture will be then completed by the exercises foreseen in the KIMOF lab.

Content

1. Design and construction of experimental facilities
2. Thermo- and fluid-dynamical analysis of experimental facilities and some components
3. Measurement techniques
4. Data acquisition and data analysis
5. Application of scaling method in experimental techniques
6. Exercise in KIMOF lab

Course: Handling Characteristics of Motor Vehicles I [2113807]

Coordinators: H. Unrau
Part of the modules: SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
Verbally

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

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

Content
1. Problem definition: Control loop driver - vehicle - environment (e.g. coordinate systems, modes of motion of the car body and the wheels)

2. Simulation models: Creation from motion equations (method according to D'Alembert, method according to Lagrange, programme packages for automatically producing of simulation equations), model for handling characteristics (task, motion equations)

3. Tyre behavior: Basics, dry, wet and winter-smooth roadway

Literature
1. Willumeit, H.-P.: Modelle und Modellierungsverfahren in der Fahrzeugdynamik,
B. G. Teubner Verlag, 1998

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

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

Course: Handling Characteristics of Motor Vehicles II [2114838]

Coordinators: H. Unrau
Part of the modules: SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

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

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

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

Literature
1. Zomotor, A.: Fahrwerktechnik: Fahrverhalten, Vogel Verlag, 1991
2. Mitschke, M./Wallentowitz, H.: Dynamik von Kraftfahrzeugen, Springer-Verlag, Berlin, 2004

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

Course: Vehicle Ergonomics [2110050]

Coordinators: T. Heine
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
Written exam (exams are only offered in German)

Conditions
None

Learning Outcomes
An ergonomic vehicle is best adapted to the requirements, needs and characteristics of its users and thus enables effective, efficient and satisfying interaction. After attending the lecture, students are able to analyse and evaluate the ergonomic quality of various vehicle concepts and derive design recommendations. They can consider aspects of both physical and cognitive ergonomics. Students are familiar with basic ergonomic methods, theories and concepts as well as with theories of human information processing, especially theories of driver behaviour. They are capable of critically reflecting this knowledge and applying it in a flexible way within the user-centered design process.

Content

- Principles of physical ergonomics
- Principles of cognitive ergonomics
- Theories of driver behaviour
- Interface design
- Usability testing

Literature
The bibliography will be published in the lecture. The slides of the lecture are available for download on ILIAS.

Course: Vehicle Comfort and Acoustics I [2113806]

Coordinators: F. Gauterin
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], (p. 465)[SP_60_mach]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture 'Vehicle Ride Comfort & Acoustics I' [2114856].

Recommendations
None.

Learning Outcomes
The students know what noises and vibrations mean, how they are generated, and how they are perceived by human beings.
They have knowledge about the requirements given by users and the public. They know which components of the vehicle are participating in which way on noise and vibration phenomenon and how they could be improved. They are ready to apply different tools and methods to analyze relations and to judge them. They are able to develop the chasis regarding driving comfort and acoustic under consideration of goal conflicts.

Content
1. Perception of noise and vibrations

3. Fundamentals of acoustics and vibrations

3. Tools and methods for measurement, computing, simulation and analysis of noise and vibrations

4. The relevance of tire and chasis for the acoustic and mechanical driving comfort:
phenomena, influencing parameters, types of construction, optimization of components and systems, conflict of goals, methods of development

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

Literature
1. Michael Möser, Technische Akustik, Springer, Berlin, 2005

2. Russel C. Hibbeler, Technische Mechanik 3, Dynamik, Pearson Studium, München, 2006

3. Manfred Mitschke, Dynamik der Kraftfahrzeuge, Band B: Schwingungen, Springer, Berlin, 1997

The script will be supplied in the lectures.

Course: Vehicle Ride Comfort & Acoustics I (eng.) [2114856]

Coordinators: F. Gauterin
Part of the modules: SP 12: Automotive Technology (p. 415)[SP_12_mach], (p. 465)[SP_60_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
Examination in English
Can not be combined with lecture 'Vehicle Comfort and Acoustics I' [2113806].

Recommendations
none

Learning Outcomes
The students are familiar with the basics of sound and vibration. They know how they are generated, how they are perceived by human beings, and which requirements are given by vehicle users and the society. Using the example of ride comfort, student have get to know basic approaches to reduce noise and vibration by an appropriate combination of elastic, damping, and inertial elements. They are ready to apply different tools and procedures, to do calculative and experimental analysis of dynamic vehicle systems and to interpret the results adequately.

Content
1. Perception of sound and vibration

2. Fundamentals of acoustics and vibration

3. Tools and methods for measurement, calculation, simulation, and analysis of sound and vibration

4. The relevance of tires for the acoustic and mechanical driving comfort: phenomena, influencing parameters, types of construction, optimization of components and systems, conflict of goals, methods of development

If possible, an excursion will be offered which gives insights in the development practice of a car manufacturer or a system supplier.

Literature
1. Zeller P (Ed.), Handbuch Fahrzeugakustik, Springer Vieweg, Wiesbaden 2018
2. Russel C. Hibbeler, Engineering Mechanics: Dynamics, Pearson, Munich 2017

3. Mitschke M, Wallentowitz H, Dynamik der Kraftfahrzeuge, Springer Vieweg, Wiesbaden 2014

The script will be supplied in the lectures.

Course: Vehicle Comfort and Acoustics II [2114825]

Coordinators: F. Gauterin
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], (p. 465)[SP_60_mach]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture 'Vehicle Ride Comfort & Acoustics II' [2114857].

Recommendations
None.

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

Content
1. Summary of the fundamentals of acoustics and vibrations

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

Literature
The script will be supplied in the lectures.

Course: Vehicle Ride Comfort & Acoustics II (eng.) [2114857]

Coordinators: F. Gauterin
Part of the modules: SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
Examination in english
Can not be combined with lecture 'Vehicle Comfort and Acoustics II' [2114825].

Recommendations
none

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

Content
The relevance of tires, road surface, wheel imperfections, springs, dampers, brakes, bearings and bushings, suspensions, engines and drive train for the acoustic and mechanical driving comfort:
- phenomena
- influencing parameters
- types of construction
- optimization of components and systems
- target conflicts
- methods of development

Noise emission of motor vehicles
- noise stress
- sound sources and influencing parameters
- legal restraints
- optimization of components and systems
- target conflicts
- methods of development

Literature
1. Zeller P (Hrsg.), Handbuch Fahrzeugakustik, Springer Vieweg, Wiesbaden 2018
2. Russel C. Hibbeler, Engineering Mechanics: Dynamics, Pearson, Munich 2017

3. Mitschke M, Wallentowitz H, Dynamik der Kraftfahrzeuge, Springer Vieweg, Wiesbaden 2014
The script will be supplied in the lectures.

Course: Vehicle Lightweight design – Strategies, Concepts, Materials [2113102]

Coordinators: F. Henning
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 50: Rail System Technology (p. 456)[SP_50_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 36: Polymer Engineering (p. 442)[SP_36_mach]

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

Learning Control / Examinations
written
duration: 90 minutes
auxiliary means: none

Conditions
none

Recommendations
none

Learning Outcomes
Students learn that lightweight design is a process of realizing a demanded function by using the smallest possible mass. They understand lightweight construction as a complex optimization problem with multiple boundary conditions, involving competences from methods, materials and production.
Students learn the established lightweight strategies and ways of construction. They know the metallic materials used in lightweight construction and understand the relation between material and vehicle body.

Content
strategies in lightweight design
shape optimization, light weight materials, multi-materials and concepts for lightweight design
construction methods
differential, integral, sandwich, modular, bionic
body construction
shell, space frame, monocoque
metalic materials
steal, aluminium, magnesium, titan

Course: Vehicle Mechatronics I [2113816]

Coordinators: D. Ammon
Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach]

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

Learning Control / Examinations
Written examination

Duration: 90 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

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

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

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

Course: Tires and Wheel Development for Passenger Cars [2114845]

Coordinators: G. Leister
Part of the modules: SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
None.

Recommendations
Knowledge in automotive engineering

Learning Outcomes
The students are informed about the interactions of tires, wheels and chassis. They have an overview of the processes regarding the tire and wheel development. They have knowledge of the physical relationships.

Content

1. The role of the tires and wheels in a vehicle
2. Geometrie of Wheel and tire, Package, load capacity and endurance, Book of requirement
3. Mobility strategy, Minispare, runflat systems and repair kit.
4. Project management: Costs, weight, planning, documentation
5. Tire testing and tire properties
6. Wheel technology incuding Design and manifacturing methods, Wheeltesting
7. Tire presssure: Indirect and direct measuring systems
8. Tire testing subjective and objective

Literature
Manuscript to the lecture

Course: Automotive Vision (eng.) [2138340]

Coordinators: C. Stiller, M. Lauer

Part of the modules: SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 50: Rail System Technology (p. 456)[SP_50_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach], SP 19: Information Technology of Logistic Systems (p. 420)[SP_19_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	en

Learning Control / Examinations
written exam

Conditions
none

Recommendations
Fundamentals in measurement, system and control theory, e.g. from the lecture “Measurement and Control Systems”. Furthermore, knowledge from the lecture “Machine Vision” is helpful, however, not mandatory.

Learning Outcomes
Machine perception and interpretation of the environment forms the basis for the generation of intelligent behavior. Especially visual perception opens the door to novel automotive applications. Driver assistance systems already improve safety, comfort and efficiency in vehicles. Yet, several decades of research will be required to achieve an automated behavior with a performance equivalent to a human operator. The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Machine vision and advanced information processing techniques are presented to provide a broad overview on seeing vehicles. Application examples from cutting-edge and future driver assistance systems illustrate the discussed subjects. The lecture consists out of 2 hours/week of lecture and 1 hour/week of computer exercises. In the computer exercises methods introduced in the lecture will be implemented in MATLAB and tested experimentally.

Content
1. Basics of machine vision
2. Binocular vision
3. Feature point methods
4. Optical flow
5. Object tracking and motion estimation
6. Self-localization and mapping
7. Road recognition
8. Behavior recognition

Literature
The slides of the lecture will be provided as pdf files. Further references will be announces in the lecture.

Course: Composite Manufacturing – Polymers, Fibers, Semi-Finished Products, Manufacturing Technologies [2114053]

Coordinators: F. Henning
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 50: Rail System Technology (p. 456)[SP_50_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 36: Polymer Engineering (p. 442)[SP_36_mach]

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

Learning Control / Examinations
written
duration: 90 min
auxiliary means: none

Conditions
none

Recommendations
none

Learning Outcomes
Students know different polymer resin materials and fiber materials and can deduce their character and use.
They understand the reinforcing effect of fibers in a matrix surrounding as well as the tasks of the single components in a compound. They know about the influence of the length of fibers, their mechanical characters and performance in a polymer matrix compound.
Student know the important industrial production processes for continuous and discontinuous reinforced polymer matrix compounds.

Content
Physical connections of fiber reinforcement
Use and examples
automotive construction
transport
Energy and construction
sport and recreation
resins
thermoplastics
duromeres
mechanisms of reinforcements
glas fibers
carbon fibers
aramid fibers
natural fibers
semi-finished products - textiles
process technologies - prepregs
recycling of composites

Course: FEM Workshop – constitutive laws [2183716]

Coordinators: K. Schulz, D. Weygand
Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach]

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

Learning Control / Examinations
Oral examination (ca. 30 min) in the elective module MSc, otherwise no grading
solving of a FEM problem
preparation of a report
preparation of a short presentation

Conditions
none

Recommendations
Engineering Mechanics; Advanced Mathematics; Introduction to Theory of Materials

Learning Outcomes
The student

- has the basic understanding of the materials theory and the classification of materials
- is able to independently generate numerical models using ABAQUS and can choose and apply adequate constitutive equations

Content
The course repeats the fundamentals of the theory of materials. It leads to the characterization and classification of material behavior as well as the specification by adequate material models. Here we focus on elastic, viscoelastic, plastic, and viscoplastic deformation behavior. Introducing the finite element program ABAQUS, the students learn how to analyze the material models numerically. Therefore ABAQUS-own and continuative constitutive equations are chosen.

Literature
Peter Haupt: Continuum Mechanics and Theory of Materials, Springer; ABAQUS Manual; Lecture notes

Course: Fabrication Processes in Microsystem Technology [2143882]

Coordinators: K. Bade
Part of the modules: SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
Oral examination, 20 minutes

Conditions
none

Recommendations
Lectures
Mikrosystemtechnik I [2141861] and/or II [2142874]

Learning Outcomes
The student

- collects advanced knowledge
- understands process conditions and process layout
- gains interdisciplinary knowledge (chemistry, manufacturing, physics)

Content
The lecture offers an advanced understanding of manufacturing processes in microsystem technology. Basic aspects of microtechnological processing will be introduced. With examples from semiconductor microfabrication and microsystem technology the base processing steps for conditioning and finishing, patterning, removal are imparted. Nano-patterning is covered is also included and the micro-nano interface is discussed. By the help of typical processing steps elementary mechanisms, process execution, and equipment are explained. Additionally quality control, process control and environmental topics are included

Media
pdf files of presentation sheets

Literature
M. Madou
Fundamentals of Microfabrication
CRC Press, Boca Raton, 1997
W. Menz, J. Mohr, O. Paul
Mikrosystemtechnik für Ingenieure
Dritte Auflage, Wiley-VCH, Weinheim 2005
L.F. Thompson, C.G. Willson, A.J. Bowden
Introduction to Microlithography
2nd Edition, ACS, Washington DC, 1994

Course: Manufacturing Technology [2149657]

Coordinators: V. Schulze, F. Zanger
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 10: Engineering Design (p. 412)[SP_10_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	6	Winter term	de

Learning Control / Examinations
The assessment is carried out as a written exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students ...

- are capable to specify the different manufacturing processes and to explain their functions.
- are able to classify the manufacturing processes by their general structure and functionality according to the specific main groups.
- have the ability to perform a process selection based on their specific characteristics.
- are enabled to identify correlations between different processes and to select a process regarding possible applications.
- are qualified to evaluate different processes regarding specific applications based on technical and economic aspects.
- are experienced to classify manufacturing processes in a process chain and to evaluate their specific influence on surface integrity of workpieces regarding the entire process chain.

Content
The objective of the lecture is to look at manufacturing technology within the wider context of production engineering, to provide an overview of the different manufacturing processes and to impart detailed process knowledge of the common processes. The lecture covers the basic principles of manufacturing technology and deals with the manufacturing processes according to their classification into main groups regarding technical and economic aspects. Regard is paid to classic manufacturing processes as well as new developments like additive manufacturing processes. The lecture is completed with topics such as process chains in manufacturing.
The following topics will be covered:

- Quality control
- Primary processing (casting, plastics engineering, sintering, additive manufacturing processes)
- Forming (sheet-metal forming, massive forming, plastics engineering)
- Cutting (machining with geometrically defined and geometrically undefined cutting edges, separating, abrading)
- Joining
- Coating
- Heat treatment and surface treatment
- Process chains in manufacturing

This lucture provides an excursion to an industry company.

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Solid State Reactions and Kinetics of Phase Transformations (with exercises) [2193003]

Coordinators: P. Franke
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
Oral examination (30 min)

Conditions

- Bacic course in materials science and engineering
- Basic course mathematics
- physical chemistry

Recommendations
knowledge of the course “Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria” (Seifert)

Learning Outcomes
The students acquire knowledge about:

- diffusion mechanisms
- Fick’s laws
- basic solutions of the diffusion equation
- evaluation of diffusion experiments
- interdiffusion processes
- the thermodynamic factor
- parabolic growth of layers
- formation of pearlite
- microstructural transformations according to the models of Avrami and Johnson-Mehl
- TTT diagrams

Content
1. Crystal Defects and Mechanisms of Diffusion
2. Microscopic Description of Diffusion
3. Phenomenological Treatment
4. Diffusion Coefficients
5. Diffusion Problems; Analytical Solutions
6. Diffusion with Phase Transformation
7. Kinetics of Microstructural Transformations
8. Diffusion at Surfaces, Grain Boundaries and Dislocations
9. Numerical treatment of diffusion controlled phase transformations

Literature
1. J. Crank, „The Mathematics of Diffusion“, 2nd Ed., Clarendon Press, Oxford, 1975.
2. J. Philibert, „Atom Movements“, Les Éditions de Physique, Les Ulis, 1991.
3. D.A. Porter, K.E. Easterling, M.Y. Sherif, „Phase Transformations in Metals and Alloys“, 3rd edition, CRS Press, 2009.
4. H. Mehrer, „Diffusion in Solids“, Springer, Berlin, 2007.

Course: Finite Element Workshop [2182731]

Coordinators: C. Mattheck, D. Weygand, I. Tesari
Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach]

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

Learning Control / Examinations
certificate in case of regular attendance

Conditions
Continuum Mechanics

Learning Outcomes
The student can

- perform stress analysis for simple components using the commercial software package ANSYS
- utilise the method of the tensile triangle to optimize the shape of components with respect to stress distribution

Content
The students will learn the foundations of the FEM stress analysis and the optimization methode 'Zugdreiecke'.

Course: Finite Volume Methods for Fluid Flow [2154431]

Coordinators: C. Günther
Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
None.

Recommendations
Fundamental Knowledge about Fluid Mechanics

Learning Outcomes
Students can describe all fundamental aspcets of the finite volume methods, which form the basis for a number of different commerical CFD codes. Students become familiar with the basics of the generation of unstructured meshes.

Content
The Finite Volume Method (=FVM) is nowadays of great interest, as it guarantees conservation of all relevant variables and as it can be used on nearly arbitrary meshes. By this it is a fundamental tool for numerical simulation of flows, which plays an ever growing role for construction and engineering and is the basis of several commercial or research codes as CFX, STAR-CCM+, FLUENT or OpenFOAM. The lecture is concerned with all aspects of FVM, mesh generation is also included. Newer developments as CVFEM (control volume based FEM) are described.

- Introduction
- Conservative schemes
- Finite volume method
- Analysis of FVM
- CVFEM as conservative FEM
- FVM for Navier-Stokes Equations
- Basics of mesh generation

Remarks
The lecture is recommended for students of mechanical, chemical or electrical engineering and is also of interest for people which are interested in FVM in a context other than fluid flow problems.

Course: Fluid Mechanics of Turbulent Flows [6221806]

Coordinators: M. Uhlmann
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
graded:
oral examination, 30 minutes

Conditions
None.

Learning Outcomes
Introduction to the physics of turbulent flows and the problem of computing them, statistical analysis of turbulent field data, detailed description of currently used statistical turbulence models (Reynolds-averaging as well as spatial filtering), discussion of model performance and range of applicability

Content
Fluid Mechanics of Turbulent Flows: General introduction to turbulent flows, Equations of fluid motion, Statistical description of turbulence, Free shear flows, The scales of turbulent motion, Wall-bounded shear flows, DNS as numerical experiments

Literature
Literature: S.B. Pope “Turbulent flows”, Cambridge University Press, 2000. U. Frisch “Turbulence: The legacy of A.N. Kolmogorov”, Cambridge U. Press, 1995. P.A. Durbin and P.A. Petterson Reif. “Statistical theory and modeling for turbulent flows”, Wiley, 2001. D.C. Wilcox “Turbulence Modeling for CFD”, DCW Industries, second edition, 1998.

Course: Fluid-Structure-Interaction [2154401]

Coordinators: M. Mühlhausen, B. Frohnapfel
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
oral exam
Duration: 30 min
no auxiliary means

Conditions
none

Recommendations
Basic Knowledge about Fluid Mechanics

Learning Outcomes
The students are familiar with the numerical treatment of coupled problems and can explain this coupling with examples. After completing this course students are able to describe a fluid-structure coupled problem and to derive its numerical formulation. They are familiar with the different coupling possibilities between the two regions and can contrast the respective advantages and disadvantages. The students can describe specific problems as occur due to the coupling; furthermore, they are capable to outline strategies to overcome such issues. Finally, the students are aware of the fact that not every result of a numerical simulation necessarily reflects reality and can thus critically judge the numerically obtained results.

Content
The lecture first introduces/recalls the fundamental governing equations that describe fluids and structures. After the characterization of the problem, the relevant equations are discussed and geometry and grid generation are treated. The resulting partial differential equations are transformed into an algebraic set of equations using different DFG and CSD methods and discretization schemes. Different methods for fluid structure coupling are introduced, where the resulting stability problem is treated in detail. Finally, the obtained result is critically examined in terms of errors and inaccuracy and verification and validation procedures are introduced.
The lecture includes an introduction to function of CFG-Programs and Matlab routines that are related to the theoretically discussed approaches.

Literature
will be introduced during the lecture

Remarks
Block course with limited number of participants, registration in the secretary's office required.
See details at www.istm.kit.edu

Course: Fluid Technology [2114093]

Coordinators: M. Geimer, M. Scherer, L. Brinkschulte
Part of the modules: SP 34: Mobile Machines (p. 441)[SP_34_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach]

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

Learning Control / Examinations
The assessment consists of a writen exam (90 minutes) taking place in the recess period.

Conditions
None.

Learning Outcomes
The students will be able to

- know and understand physical principles of fluid power systems
- know the current components and their operating mode
- know the advantages and disadvantages of different components
- dimension the components for a given purpose
- calculate simple systems

Content
In the range of hydrostatics the following topics will be introduced:

- Hydraulic fluids
- Pumps and motors
- Valves
- Accessories
- Hydraulic circuits.

In the range of pneumatics the following topics will be introduced:

- Compressors
- Motors
- Valves
- Pneumatic circuits.

Literature
download of lecture Fluidtechnik slides via ILIAS

Course: Fusion Technology A [2169483]

Coordinators: R. Stieglitz, Fietz, Day, Boccaccini
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach]

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

Learning Control / Examinations
oral: Acceptance for the oral test only by certification of attendance of excercises
(can be given in english)
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
appreciated is knowldege in heat ans mass transfer as well as in electrical engineering
Basic knowledge in fluid mechanics, material sciences and physics

Learning Outcomes
The lecture describes the functional principle of a fusion reactor, starting from the plasma and its confinement options, the magnets, the tritium and fuel cycle, the vacuum technology and the associated material sciences. The physical principles are discussed and scaling laws are formulated. One major emphasis is directed towards the interface between the individual fields of disciplines which to a large extend determines the technological scaling of a fusion facility.Here methods are communicated, which allow for an identification of central parameters and a corresponding technical analysis. Based on the elaborated acquisition skills appoaches to design solution strategies are transmitted. Also technical solutions are shown and the weaknesses are discussed and evaluated.

Content
Actual energy situation and perspectives. Elementary particle physics, principles of nuclear fusion and nuclear fission. What is a plasma and how it can be confined? How stable is a plasma and condtions for an ignition , control of a plasma and transport in plasmas. Plasmas are confined contactless by means of magnetic fields. Hence fundamentals of the magnet technology, super-conductivity, materials in super-conductivity, fabrication and design of magnets are elaborated.A fusion reactor breeds is own fuel Tritium, which is radioactive. Tritium poses specific requirements regarding separation, conditioning and the fuel cycle, for which the physical and technological basis are outlined. Fusion plasmas are characterized by a small particle density and hence a vacuum is required. Simultaneously plasmas generate high temperatures and heat loads necessitating dedicated designs of plasma facing components at a considerable neutron irradiation. in both technology fields the tasks, requirements and challenges are formulated and how they translate to the current “state of the art” are illustrated. Moreover, an introduction into design criteria and calculation methods to select adequate vacuum pumps and to design plasma facing components is provided.

Media
Päsentation (transparencies nearly exclusivley in english) complemented by print-outs

Literature
Within each subblock an adequate selection of literature is given. Additionally the students get the lecuture materials in printed and electronic version.

Course: Fusion Technology B [2190492]

Coordinators: R. Stieglitz, Fischer, Möslang, Gantenbein
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach]

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

Learning Control / Examinations
oral
Completed set of practical courses within lecture

Duration: approximately 25 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
attendance of fusion technology A lecture
reliable capability to use fundamental knowledge communicated in the bachelor study in physics, material sciences , electrical engineering and engineering design

Learning Outcomes
Goal of the lecture is the transfer of fundamental knowledge in material science under irradiation, nuclear physics, plasma heating technologies and the specific environment of nuclear installations (nulcear safety and scaling). In this context the focus is directed towards the elaboration of the physics fundamentals and the corresponding computational methods. Another focus is to enable the identifaction of interfaces between different technical systems and the education to assess their functionality. At the end of each block the knowledge is applied to current state of the art systems developed.
The lecutre is accompanied by excercises at the campus north (2-3 noons per topic)

Content
Fusiontechnology B comprises the following content:Fusion neutronics, material sciences under irradiation, plasma heating-and current drive methods as well as reactor safty and scaling.
The section fusion neutronics scopes the fundamentals and calculation methods, which allows for a physical design of a nuclear fusion reactor and the corresponding components (such as blankets, divertors, shielding, activation and shut down dose rate).
Within the material sciences the fundamentals of material sciences are refreshed in order to discuss subsequently material defects originating mainly from neutron irradiation. Based on this critiera to modify material properties are elaborated and options/methods to optimize materials as well as to select them adequately are deduced.
The arrangement of the plasma facing components in a fusion power plant translated into challenging demands for the system integration and energy conversion. To ignite the plasma extreme temperatures of several million degrees are required. For this purpose, special plasma heating techniques are used such as electron cyclotron resonance heating (ECRH), ion-cyclotron resonance heating (ICRH), the current drive at the lower hybrid frequency, and the neutral particle injection. Their basic mode of action, the design criteria, the transmission options and performance are presented and discussed. Additionally the heating method used also for plasma stabilization. Here are some considerations and limitations are presented.
A fusion power plant is a nuclear facility and hence it is subject of a nuclear safety evaluation and demonstration. In this context the fundamentals of the analysis and assessment of nuclear plants are described starting from the safety concept to its demonstration with the corresponding computational methods.

Media
presentation and complementing printouts, material is regularly provided via ILAS (password protected)

Literature
Lecture notes

McCracken, Peter Scott, Fusion, The Energy of Universe, Elsevier Academic Press, ISBN: 0-12-481851-X
additional literature sources for the individual topics is provided.

Course: Combined Cycle Power Plants [2170490]

Coordinators: T. Schulenberg
Part of the modules: SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach]

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

Learning Control / Examinations
Oral Examination ca. 30 min

Conditions
None.

Recommendations
Knowlegde in thermodynamics, heat and mass transfer, instrumentation and control, and turbomachines is presumed.
We recommend to combine the lecture with the Simulator Exercises for Combined Cycle Power Plants (2170491)

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in power plant engineering. The participants can name the most important components of the combined cycle power plant and describe their function. They can design or modify combined cycle power plants independently and creatively. They have acquired a broad knowledge of this power plant technology, including specific knowledge of gas turbine design, steam turbine design and boiler design. On this basis, they can describe and analyze the specific behavior of the power plant components as well as the entire power plant in the grid. Participants in the lecture have a trained analytical thinking and judgment in power plant design.

Content
Layout of a combined cycle power plant, design and operation of gas turbines, of the heat recovery steam generator, of the feedwater system and cooling systems. Design and operation of steam turbines, of the generator and its electrical systems. System response to challinging grids, protection systems, water make-up and water chemistry. Design concepts of different power plant manufacturers, innovative power plant concepts.

Media
Lecture with English Power Point Presentation

Literature
Power point slides, lecture notes and other lecture material will be provided.
Recommended additional literature:
C. Lechner, J. Seume, Stationäre Gasturbinen, Springer Verlag, 2. Auflage 2010

Course: Gasdynamics [2154200]

Coordinators: F. Magagnato

Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

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

Learning Control / Examinations
oral
Duration: 30 min
no auxiliary means

Conditions
none

Recommendations
basic skills in mathematics, physics and fluid dynamics

Learning Outcomes
The students can describe the governing equations of Gas Dynamics in integral form und the associated basics in Thermodynamics. They can calculate compressible flows analytically. The students know how to derive the Rankine-Hugoniot curve and the Rayleigh line and can name those. They can derive the continuity-, the momentum- and the energy equations in differential form. With the help of the stationary flow filament theory they can calculate the normal shock wave and the associated increase of entropy.
They are able to determine the stagnation values of the gas dynamic variables and to determine their critical values. The students can apply the flow filament theory for variable cross-sectional areas and can distinguish the related different flow states inside the Laval nozzle.

Content
This lecture covers the following topics:

- Introduction, basics of Thermodynamics
- Governing equations of gas dynamics
- Application of the conservation equations
- The transport equations in differential form
- Stationary flow filament theory with and without shock waves
- Discussion of the energy equation: Stagnation and critical values
- Flow filament theory for variable cross-sectional areas. Flow inside a Laval nozzle

Literature
John, J., and Keith T. Gas Dynamics. 3rd ed.
Harlow: Prentice Hall, 2006
Rathakrishnan, E. *Gas Dynamics*. Prentice Hall of India Pvt. Ltd, 2006

Course: Gas Engines [2134141]

Coordinators: R. Golloch
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

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

Learning Control / Examinations
Oral examination, duration 25 min., no auxillary means

Conditions
none

Recommendations
Knowledge about „Verbrennungsmotoren A und B“ or “Fundamentals of Combustion Engines I and II”

Learning Outcomes
The student can name and explain the function, characteristics and application areas of gas and dual fuel engines. He is able to distinguish from engines using liquid fuels. The student describe and explain gaseous fuels, engine subsystems, combustion processes and exhaust gas aftertreatment technologies. He is capable to analyse and evaluate current development areas and technical challenges.

Content
Based on the basics of internal combustion engines the students learn about functions of modern gas and dual fuel engines. Core learning areas are gaseous fuels, combustion processes including abnormal combustion characteristics, subsystems like gas admission, ignition, safety and control systems. Further knowledge will be teached on emissions, exhaust gas aftertreatment, applications and operation characteristics.

Media
Lecture with PowerPoint slides

Literature
Lecture Script, prepared by the lecturer. Obtainable at the Institut für Kolbenmaschinen
Recommended:
- Merker, Schwarz, Teichmann: Grundlagen Verbrennungsmotoren, Vieweg + Teubner Verlag 2011;
- Zacharias: Gasmotoren, Vogel Fachbuch 2001

Course: Building- and Environmental Aerodynamics [19228]

Coordinators: B. Ruck
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
Graded: oral examination, 30 minutes

Conditions
none

Recommendations
Fluid mechanics, Hydromechanics

Learning Outcomes
The students are able to analyse and calculate steady and unsteady wind loading on technical and natural structures. They know the fundamentals of wind load assessment and flow induced vibrations as well as methods to estimate their influence. Typical applications will be demonstrated linking theory to practice.

Content
The lecture gives an introduction to the field of buidling- and environmental aerodynamics. Part 1 is dedicated to building aerodynamics and to the assessment of wind loads, whereas part 2 deals with aspects of flows in natural environments.
Topics: Atmospheric boundary layer and natural wind, Wind loads on technical and natural structures, Wind induced vibrations, Wind shelter, Wind tunnel modelling

Course: Human brain and central nervous system: anatomy, information transfer, signal processing, neurophysiology and therapy [24139]

Coordinators: U. Spetzger
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach]

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

Learning Control / Examinations
The assessment is explained in the module description.

Conditions
None.

Recommendations
Prior attendance at lecture, seminars and laboratory in *Medical Simulation Systems* is recommended but not mandatory.

Learning Outcomes
The students get an insight into neuromedicine and establish a general appreciation to the field of neuroinformatics. In particular, anatomy, information transfer, signal processing, neurophysiology and therapy are covered. Furthermore, the sensoric physiology, various malfunctions of the central nervous system, diagnostic procedures and different modern therapy modalities and treatment options are introduced.

Content
The lecture wants to impart basic knowledge for students of computer sciences and bridges the information gap between engineering and medicine. The purpose is to describe the basis of the composition of the human brain with anatomical details of neural cells and nerve tissue. This represents the comprehension of the complex structure and the sequels within the human brain and spinal cord. It will improve the understanding of sensomotor-prostheses and artificial limbs and closely links to robotic systems. Furthermore, image-guided planning and computer-assisted surgical procedures in neurosurgery are demonstrated on different examples.

Media
Slides or electronic files of the presentations

Literature
Neuro- und Sinnesphysiologie Schmidt, Robert F.; Schaible, Hans-Georg (Hrsg.) 5. Auflage, 2006, Springer Verlag, ISBN: 978-3-540-25700-4 (9,95 Euro)

Course: Human brain and central nervous system: anatomy, information transfer, signal processing, neurophysiology and therapy [24678]

Coordinators: U. Spetzger
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	de

Learning Control / Examinations
The assessment is explained in the module description.

Conditions
None.

Recommendations
Prior attendance at lecture, seminars and laboratory in *Medical Simulation Systems* is recommended but not mandatory.

Learning Outcomes
The students get an insight into neuromedicine and establish a general appreciation to the field of neuroinformatics. In particular, anatomy, information transfer, signal processing, neurophysiology and therapy are covered. Furthermore, the sensoric physiology, various malfunctions of the central nervous system, diagnostic procedures and different modern therapy modalities and treatment options are introduced.

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Media
Slides or electronic files of the presentations

Literature
Neuro- und Sinnesphysiologie Schmidt, Robert F.; Schaible, Hans-Georg (Hrsg.) 5. Auflage, 2006, Springer Verlag, ISBN: 978-3-540-25700-4 (9,95 Euro)

Course: Appliance and Power Tool Design [2145164]

Coordinators: S. Matthiesen
Part of the modules: SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	4	Summer term	de

Learning Control / Examinations
Oral examination
Duration: 30 min
Auxiliary means: none
Combined examination of lecture and project work.

Conditions
In Masters Course:
The participationin " Appliance and power tool design"" requires the concurrent project work.
Due to organizational reasons, the number of participants is limited. At the beginning of august, a registration form will be available at the IPEK website. In the case of too many applicants, a selection process will be taking place. An early application is advantageous.

Recommendations
CAE Workshop is recommended as elective course or complementary subject.

Learning Outcomes
The students are able to ...

- analyze complex and contradictory problems regarding the overall system user –machine and hence to create new solutions with focus on customer use.
- list, to identify and to explain strategies and approaches for the design of technical machines, to transfer them on new problems and to evaluate the working results concerning quality, costs and customer use.
- name the impact of specific boundary conditions, e.g. high quantities of mechatronic systems considering the customer, on the resulting design, to interpret the consequences and to evaluate the effects in unknown situations.
- name aspects of a successful product engineering in a team of worldwide acting companies regarding the field customer, company and market.
- evaluate their relevance for self-chosen examples and to transfer them on unknown problems.

Content
Operation system, system of objects and system of objectives of mechatronic appliances and power tool designs.
Mode of operation as enabler of design, components of mechatronic systems, application oriented design, guidelines for appliance and power tool design.
Part of the lecture is a project work, in which theory will be reprocessed and presented in a practical way. In such exercises the students also will present their results developed in project teams.
The interaction of analysis and sysnthesis will be acquired in student teams at the example of different appliances and power tools.

Course: Foundry Technology [2174575]

Coordinators: C. Wilhelm
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 25: Lightweight Construction (p. 427)[SP_25_mach]

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

Learning Control / Examinations
oral exam; about 25 minutes

Conditions
Materials Science I & II must be passed.

Learning Outcomes
The students know the specific moulding and casting techniques and are able to describe them in detail. The students know the application of moulding and casting techniques concerning castings and metals, their advantages and disadvantages in comparison, their application limits and are able to describe these in detail.
The students know the applied metals and are able to describe advantages and disadvantages as well as the specific range of use.
The students are able, to describe detailed mould and core materials, technologies, their application focus and mould-affected casting defects.
The students know the basics of casting process of any casting parts concerning the above mentioned criteria and are able to describe detailed.

Content
Moulding and casting processes
Solidifying of melts
Castability
Fe-Alloys
Non-Fe-Alloys
Moulding and additive materials
Core production
Sand reclamation
Design in casting technology
Casting simulation
Foundry Processes

Literature
Reference to literature, documentation and partial lecture notes given in lecture

Course: Global Production and Logistics - Part 1: Global Production [2149610]

Coordinators: G. Lanza
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

Learning Control / Examinations
Performance is assessed in the form of one oral examination in the case of “Kernfach”. Therefore, the examination date can be defined individually.
Performance is assessed in the form of one written examination during the lecture-free period.
The examination will take place once every semester and can be retaken at every official examination date.

Conditions
None

Recommendations
Combination with Global Production and Logistics – Part 2

Learning Outcomes
The students . . .

- can explain the general conditions and influencing factors of global production.
- are capable to apply defined procedures for site selection and to evaluate site decisions with the help of different methods.
- are able to select the adequate scope of design for site-appropriate production and product construction case-specifically.
- can state the central elements in the planning process of establishing a new production site.
- are capable to make use of the methods to design and scale global production networks for company-individual problems.
- are able to show up the challenges and potentials of the departments sales, procurement as well as research and development on global basis.

Content
Target of the lecture is to depict the challenges and fields of action of global operating companies and to give an overview of central aspects in global production networks as well as establishing a deepening knowledge of established methods and procedures for design and scale. Within the course methods for site selection, procedures for site specific adjustment of product construction and product technology as well as planning approaches to establish a new production site are imparted. The course is rounded off by showing the characteristics of the departments sale, procurement as well as research and development under global aspects. Moreover, the implementation of Industry 4.0 applications is discussed in the context of global production.
The topics are:

- Basic conditions and influencing factors of global production (historical development, targets, chances and threats)
- Global sales
- Site selection
- Site specific producion adjustment
- Establishing of new production sites
- Global procurement

- Design and management of global production networks
- Global research and development

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes
recommended secondary literature:
Abele, E. et al: Global Production – A Handbook for Strategy and Implementation, Springer 2008 (english)

Remarks
None

Course: Global Production and Logistics - Part 2: Global Logistics [2149600]

Coordinators: K. Furmans, O. Zimmermann
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

Learning Control / Examinations
A performance assessment is obligatory and can be oral, a written exam, or of another kind.

Conditions
none

Recommendations
We recommend the course "Logistics - organisation, design and control of logistic systems " (2118078) beforehand.

Learning Outcomes
Students are able to:

- assign basic problems of planning and operation of global supply chains and plan them with apropriate methods,
- describe requirements and characteristics of global trade and transport, and
- evaluate characteristics of the design from logistic chains regarding their suitability.

Content
Characteristics of global trade

- Incoterms
- Customs clearance, documents and export control

Global transport and shipping

- Maritime transport, esp. container handling
- Air transport

Modeling of supply chains

- SCOR model
- Value stream analysis

Location planning in cross-border-networks

- Application of the Warehouse Location Problem
- Transport Planning

Inventory Management in global supply chains

- Stock keeping policies

Inventory management considering lead time and shipping costs

Media
presentations, black board

Literature
Elective literature:

- Arnold/Isermann/Kuhn/Tempelmeier. HandbuchLogistik, Springer Verlag, 2002 (Neuauflage in Arbeit)
- Domschke. Logistik, Rundreisen und Touren,Oldenbourg Verlag, 1982
- Domschke/Drexl. Logistik, Standorte, OldenbourgVerlag, 1996
- Gudehus. Logistik, Springer Verlag, 2007
- Neumann-Morlock. Operations-Research,Hanser-Verlag, 1993
- Tempelmeier. Bestandsmanagement in SupplyChains, Books on Demand 2006
- Schönsleben. IntegralesLogistikmanagement, Springer, 1998

Course: Fundamentals of Energy Technology [2130927]

Coordinators: A. Badea, X. Cheng
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	5	Summer term	de

Learning Control / Examinations
written

Conditions
Can not be combined with lecture 'Fundamentals of Energy Technology' [3190923].

Learning Outcomes
The students will receive state of the art knowledge about the very challenging field of energy industry and the permanent competition between the economical profitability and the long-term sustainability.

Content
The following relevant fields of the energy industry are covered:
- Energy demand and energy situation
- Energy types and energy mix
- Basics. Thermodynamics relevant to the energy sector
- Conventional fossil-fired power plants
- Combined Cycle Power Plants
- Cogeneration
- Nuclear energy
- Regenerative energies: hydropower, wind energy, solar energy, other energy systems
- Energy demand structures. Basics of economic efficiency and calculus. Optimization
- Energy storage
- Transport of energy
- Power generation and environment. Future of the energy industry

Course: Automotive Engineering I [2113805]

Coordinators: F. Gauterin, H. Unrau
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	4	Winter term	de

Learning Control / Examinations
Written examination

Duration: 120 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture 'Automotive Engineering I' [2113809].

Recommendations
None.

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

Content
1. History and future of the automobile
2. Driving mechanics: driving resistances and driving performances, mechanics of the longitudinal and transverse forces, passive safety

3. Engines: combustion engine, alternative drives (e.g. electric motor, fuel cell)

4. Transmission: clutches (e.g. friction clutch, visco clutch), transmission (e.g. mechanical transmission, hydraulic fluid transmission)

5. Power transmission and distribution: drive shafts, cardon joints, differentials

Literature
1. Mitschke, M./ Wallentowitz, H.: Dynamik der Kraftfahrzeuge, Springer-Verlag, Berlin, 2004

2. Braes, H.-H.; Seiffert, U.: Handbuch Kraftfahrzeugtechnik, Vieweg&Sohn Verlag, 2005

3. Gnadler, R.: Script to the lecture 'Automotive Engineering I'

Course: Automotive Engineering I (eng.) [2113809]

Coordinators: F. Gauterin, M. Gießler

Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 10: Engineering Design (p. 412)[SP_10_mach]

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

Learning Control / Examinations
Written examination

Duration: 120 minutes

Auxiliary means: none

Conditions
Examination in English
Can not be combined with lecture 'Automotive Engineering I' [2113805].

Recommendations
none

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

Content
1. History and future of the automobile

2. Driving mechanics: driving resistances and driving performance, mechanics of longitudinal and lateral forces, active and passive safety

3. Drive systems: combustion engine, hybrid and electric drive systems

4. Transmissions: clutches (e.g. friction clutch, visco clutch), transmission (e.g. mechanical transmission, hydraulic fluid transmission)

5. Power transmission and distribution: drive shafts, cardon joints, differentials

Literature
1. Robert Bosch GmbH, Automotive Handbook, 9th Edition, Wiley, Chichester 2015

2. Onori S, Serrao L, Rizzoni G, Hybrid Electric Vehicles - Energy Management Strategies, Springer London, Heidelberg, New York, Dordrecht 2016
3: Reif K, Fundamentals of Automotive and Engine Technology, Springer Vieweg, Wiesbaden 2014
4: Reif K, Brakes, Brake Control and Driver Assistance Systems - Function, Regulation and Components, Springer Vieweg, Wiesbaden 2015
5: Gauterin F, Unrau H-J, Gießler M, Gnadler R, Script to the lecture 'Automotive Engineering I', KIT, Institute of Vehicle System Technology, Karlsruhe, annual update

Course: Automotive Engineering II [2114835]

Coordinators: H. Unrau
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach]

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

Learning Control / Examinations
Written Examination

Duration: 90 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture 'Automotive Engineering II' [2114855].

Recommendations
None.

Learning Outcomes
The students have an overview of the modules, which are necessary for the road holding of a motor vehicle and the power transmission between vehicle bodywork and roadway. They have knowledge of different wheel suspensions, the tyres, the steering elements and the brakes. They know different execution forms, the function and the influence on the driving or brake behavior. They are able to develop the appropriate components correctly. They are ready to analyze, to judge and to optimize the complex relationship of the different components under consideration of boundary conditions.

Content
1. Chassis: Wheel suspensions (rear axles, front axles, kinematics of axles), tyres, springs, damping devices
2. Steering elements: Manual steering, servo steering, steer by wire
3. Brakes: Disc brake, drum brake, retarder, comparison of the designs

Literature
1. Heißing, B./Ersoy, M.: Fahrwerkhandbuch: Grundlagen, Fahrdynamik, Komponenten, Systeme, Mechatronik, Perspektiven, Vieweg-Verlag, Wiesbaden, 2011

2. Breuer, B./Bill, K.-H.: Bremsenhandbuch: Grundlagen - Komponenten - Systeme - Fahrdynamik, Vieweg-Verlag, Wiesbaden, 2012

3. Gnadler, R.: Script to the lecture 'Automotive Engineering II'

Course: Basic principles of powder metallurgical and ceramic processing [2193010]

Coordinators: G. Schell, R. Oberacker
Part of the modules: SP 43: Technical Ceramics and Powder Materials (p. 449)[SP_43_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
The assessment consists of an oral exam (20-30 min) taking place at the agreed date. The re-examination is offered upon agreement.

Conditions
None.

Recommendations
Knowledge of basic material science is assumed

Learning Outcomes
The students know the basics of characterization of powders, pastes and suspensions. They have a fundamental understanding of the process technology for shaping of particulate systems. They are able to use these fundamentals to design selected wet- and dry forming processes.

Content
The course covers fundamentals of the process technology for shaping of ceramic or metal particle systems. Important shaping methods are reviewed. The focus is on characterization and properties of particulate systems, and, in particular, on process technology for shaping of powders, pastes, and suspensions.

Media
Slides for the lecture:
available under http://ilias.studium.kit.edu

Literature

- R.J. Brook: Processing of Ceramics I+II, VCH Weinheim, 1996
- M.N. Rahaman: Cermamic Processing and Sintering, 2nd Ed., Marcel Dekker, 2003
- W. Schatt ; K.-P. Wieters ; B. Kieback. „Pulvermetallurgie: Technologien und Werkstoffe“, Springer, 2007
- R.M. German. “Powder metallurgy and particulate materials processing. Metal Powder Industries Federation, 2005
- F. Thümmler, R. Oberacker. “Introduction to Powder Metallurgy”, Institute of Materials, 1993

Course: Fundamentals of catalytic exhaust gas aftertreatment [2134138]

Coordinators: E. Lox, H. Kubach, O. Deutschmann, J. Grunwaldt
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach]

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

Learning Control / Examinations
oral examination, Duration: 25 min., no auxiliary means

Conditions
none

Recommendations
Combustion engines I helpful

Learning Outcomes
The students can name and explain the scientific fundamentals of the catalytic exhaust gas aftertreatment, as well as the technical, political and economical parameters of its application in engines for passenger cars and HD vehicles.

The students are able to point out and explain which emissions are formed in combustion engines, why these emissions are helth-related critical and which measures the legislator has established to reduce the emissions.

Content
1. kind and source of emissions
2. emission legislation
3. principal of catalytic exhaust gas aftertreatment (EGA)
4. EGA at stoichiometric gasoline engines
5. EGA at gasoline engines with lean mixtures
6. EGA at diesel engines
7. economical basic conditions for catalytic EGA

Literature
Lecture notes available in the lectures

1. "Environmental Catalysis" Edited by G.Ertl, H. Knötzinger, J. Weitkamp Wiley-VCH Verlag GmbH, Weinheim, 1999 ISBN 3-527-29827-4
2. "Cleaner Cars- the history and technology of emission control since the 1960s" J. R. Mondt Society of Automotive Engineers, Inc., USA, 2000 Publication R-226, ISBN 0-7680-0222-2
3. "Catalytic Air Pollution Control - commercial technology" R. M. Heck, R. J. Farrauto John Wiley & Sons, Inc., USA, 1995 ISBN 0-471-28614-1
4. "Automobiles and Pollution" P. Degobert Editions Technic, Paris, 1995 ISBN 2-7108-0676-2
5. "Reduced Emissions and Fuel Consumption in Automobile Engines" F. Schaeder, R. van Basshuysen, Springer Verlag Wien New York, 1995 ISBN 3-211-82718-8
6. "Autoabgaskatalysatoren : Grudlagen - Herstellung - Entwicklung - Recycling - Ökologie" Ch. Hagelüken und 11 Mitautoren, Expert Verlag, Renningen, 2001 ISBN 3-8169-1932-4

Course: Principles of Medicine for Engineers [2105992]

Coordinators: C. Pylatiuk
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach]

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

Learning Control / Examinations
written examination

Conditions
None.

Recommendations
Organ support systems

Learning Outcomes
Students have fundamental knowledge about functionality and anatomy of organs within different medical disciplines. The students further know about technical methods in diagnosis and therapy, common diseases, their relevance and costs. Finally the students are able to communicate with medical doctors in a way, in which they prevent misunderstandings and achieve a more realistic idea of each others expectations.

Content

- Introduction: Definitions of "health" and "disease". History of medicine and paradigm shift towards evidence based medicine and personalized medicine.
- Special topics: nervous system, saltatory conduction, musculoskeletal system, cardio-circulatory system, narcosis, pain, respiratory system, sensory organs, gynaecology, digestive organs, surgery, nephrology, orthopaedics, immune system, genetics.

Literature

- Adolf Faller, Michael Schünke: Der Körper des Menschen. Thieme Verlag.
- Renate Huch, Klaus D. Jürgens: Mensch Körper Krankheit. Elsevier Verlag.

Course: Introduction to Microsystem Technology I [2141861]

Coordinators: J. Korvink, V. Badilita, M. Jouda
Part of the modules: SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
The subject is concluded with a **written examination**, which can be take twice a year during the lecture breaks. For details, see the notes below.

Conditions
None.

Learning Outcomes
The lectures provide an **introduction** to the fundamentals of microsystems technology. In analogy to processes employed in the fabrication of microelectronics circuits, the **core technologies** as well as materials for producing microstructures and components are presented. Various techniques for Silicon micromachining are explained, and illustrated with **examples** for micro-components and micro-systems. Each chapter starts with its own learning goals, and ends with typical **examination questions**.

Content
The chapters are:

- **MST overview**. The broad concepts of microsystems technology are discussed.
- **Silicon wafers**. How silicon wafers are produced.
- **Technologies overview**. Which technologies typically arise in semiconductor manufacturing.
- **Solid state**. The peculiarities of the solid state, such as the arising of a band structure in semiconductors.
- **Crystal structure analysis**. How the properties of crystals are experimentally determined.
- **Materials**. Which material classes and materials are relevant in microsystems.
- **Vacuum**. The role of vacuum in semiconductor processing, and how to create vacuum.
- **Electrochemistry and electroplating**. The basics of electrochemistry, and how it can be used to form material layers.
- **Thin layers and films**. The role and properties of very thin films of materials, and how they are formed.
- **General dry etching**. How dry etching works in general.
- **Silicon dry etching**. How silicon can be anisotropically etched using gases.
- **Silicon wet etching**. How silicon can be anisotropically etched to form interesting structures.
- **Surface micromachining**. How structures are formed on the surface of a wafer.
- **Examples**. Examples of MEMS are discussed in more detail.

Literature
W. Menz, J. Mohr, O. Paul
Microsystem Technology,
Wiley-VCH, Weinheim 2005
M. Madou
Fundamentals of Microfabrication and Nanotechnology
CRC Press, 2011

Remarks
Written examinations and **practica** are offered during the lecture-free period, **twice a year**. The exact dates are communicated at the start of the semester, and follow the rule:

- The **MST practicum** takes place during the **week of Ash Wednesday** in Springtime, and in the **first full week of September** during Autumn (Fall).
- The **examination** falls on the **Thursday after the practicum** week, and is scheduled for **8:00 o'clock** in the morning.

Students may take **written examinations** in **all and any** of the following subjects on the day of the examination:

- (1 hour duration) Introduction to Microsystem Technology I
- (1 hour duration) Introduction to Microsystem Technology II
- (1 hour duration) MST practicum

The examination is given in German and English, we accept answeres in both languages. Additional resources are restricted to wordbooks of you mother tongue.

Course: Introduction to Microsystem Technology II [2142874]

Coordinators: J. Korvink, M. Jouda
Part of the modules: SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
The subject is concluded with a **written examination**, which can be take twice a year during the lecture breaks. For details, see the notes below.

Conditions
None.

Learning Outcomes
The lectures provide an **deeper insight** to the fundamentals of microsystems technology, and expand upon the topics from *Introduction to Microsystem Technology I*. More focus is placed on modern manufacturing processes which are extending the basic Silicon micromachining palette, such as nanolithography, 3D printing, and inkjet manufacturing. Each chapter starts with its own learning goals, and ends with typical **examination questions**.

Content
The chapters are:

- **Introduction**. How the market is changing, and driving MST. What the cutting edge of MST is about. How thin substrates are an enabler for future product revolutions. The modelling of microsystem effects. Definition of a system.
- **Mainstream lithography**. History of lithography. Reminder of Moore's law. Types of lithography. Resists. Masks. Mask details. Procedures. X-ray lithography in brief.
- **Lithography variants**. Responsive materials. Combining lithography with other processes. Two-photon methods. Scanning probe methods.
- **Rapid prototyping I & II**. General introduction. Fused deposition modeling. Laser sintering. Binder jetting. Laminated object manufacturing. Inkjet printing. Laser-induced forward transfer. Electrochemical. Electron beam melting. Bioprinting. Milling. Electrical discharge milling. Water jet cutting. Laser micromachining. Reasons for rapid prototyping. Advantages and disadvantages. Potential of rapid prototyping.
- **Unconventional processes I & II**. Thinking outside the box. Printed circuit board methods. Rolled up MEMS. Wirebonding. Focused ion beam. Atomic layer deposition.
- **Micro replication processes**. Introduction. Injection moulding. Reaction injection moulding. Hot embossing. Thermoforming. Blow moulding. Comparison.
- **Materials I**. Functions of a MEMS material. Feedstock types. Materials manufacturing. Spin coating. Langmuir-Blodgett films. Dip coating. Spray coating. Dispensing. Screen printing. Laser assisted processing. Inkjetting (again). Xerography. Laser assisted printing (again). Offset printing. Microcasting. MIM (again). Plasma bonding. Layering and laminating.
- **Materials II**. Material formations. Property engineering. Homogenisation. Bandgap engineering. Metamaterials. Bulk vs. film properties. Property measurements for electrical, magnetic, mechanical and other properties. In situ testing. Various measurement techniques.
- **Self assembly**. Bottom up. Types of self-assembly. Models. Forces. Enthalpy and entropy. Block copolymers. DNA origami. Directed assembly. Surface tension. Soft origami. Device assembly processes. Janus materials.
- **Exotica**. Fascinating ideas from the literature. This section is often updated and is not examined but only presented for interest.

Literature
W. Menz, J. Mohr, O. Paul
Microsystem Technology,
Wiley-VCH, Weinheim 2005
M. Madou
Fundamentals of Microfabrication and Nanotechnology
CRC Press, 2011

Remarks
Written examinations and **practica** are offered during the lecture-free period, **twice a year**. The exact dates are communicated at the start of the semester, and follow the rule:

- The **MST practicum** takes place during the **week of Ash Wednesday** in Springtime, and in the **first full week of September** during Autumn (Fall).
- The **examination** falls on the **Thursday after the practicum** week, and is scheduled for **8:00 o'clock** in the morning.

Students may take **written examinations** in **all and any** of the following subjects on the day of the examination:

- (1 hour duration) Introduction to Microsystem Technology I
- (1 hour duration) Introduction to Microsystem Technology II
- (1 hour duration) MST practicum

The examination is given in German and English, we accept answeres in both languages. Additional resources are restricted to wordbooks of you mother tongue.

Course: Foundations of nonlinear continuum mechanics [2181720]

Coordinators: M. Kamlah
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach]

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

Learning Control / Examinations
oral exam 30 minutes

Conditions
None.

Recommendations
Engineering Mechanics - Advanced Mathematics

Learning Outcomes
The students understand the fundamental structure of a continuum theory consisting of kinematics, balance laws and constitutive model. In particular, they recognize non-linear continuum mechanics as a common structure including all continuum theories of thermomechanics, which are obtained by adding a corresponding constitutive model. The students understand in detail the kinematics of finite deformation and know the transition to the geometrically linear theory they are familiar with. The students know the spatial and material representation of the theory and the different related tensors. The students take the balance laws as physical postulates and understand their respective physical motivation.

Content
The lecture is organized in three parts. In the first part, the mathematical foundations of tensor algebra and tensor analysis are introduced, usually in cartesian representation. In the second part of the lecture, the kinematics, i.e. the geometry of deformation is presented. Besides finite deformation, geometric linearization is discussed. The thrid part of the lecture deals with the physical balance laws of thermomechanics. It is shown, how a special classical theory of continuum mechanics can be derived by adding a corresponding constitutive model. For the illustration of the theory, elementary examples are discussed repeatedly.

Literature
lecture notes

Course: Fundamentals of X-ray Optics I [2141007]

Coordinators: A. Last
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
oral examination; date request by email

Conditions
None.

Recommendations
This lecture addresses to students in mechanical engineering and physics interested in X-ray optics.
basics in optics
additional lecture: accelerator physics I/II (2208111)
http://www.imt.kit.edu/x-rayoptics.php

Learning Outcomes
The lecture will enable the students to judge capabilities of different X-ray optical imaging methods and instrumentation and to select suitable methods for a given task.

Content
The lecture covers general principles of optics as well as basics, functioning and application of reflective, refractive and diffractive X-ray optical elements and systems. Selected X-ray analytical imaging methods and the necessary optical elements are discussed including their potentials and limitations.

Literature
M. Born und E. Wolf
Principles of Optics, 7th (expanded) edition
Cambridge University Press, 2010
A. Erko, M. Idir, T. Krist und A. G. Michette
Modern Developments in X-Ray and Neutron Optics
Springer Series in Optical Sciences, Vol. 137
Springer-Verlag Berlin Heidelberg, 2008
D. Attwood
Soft X-Rays and Extreme Ultraviolet Radiation: Principles and Applications
Cambridge University Press, 1999

Remarks
Lecture dates will be fixed in agreement with the students, see institutes website.
A visit at synchrotron ANKA is possible if requested.

Course: Basics of Technical Logistics [2117095]

Coordinators: M. Mittwollen, J. Oellerich
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

Learning Control / Examinations
after each lesson period; oral / written (if necessary)

Conditions
None.

Recommendations
None.

Learning Outcomes
Students are able to:

- Describe processes and machines of technical logistics,
- Model the fundamental structures and the impacts of material handling machines with mathematical models,
- Refer to industrially used machines and
- Model real machines applying knowledge from lessons and calculate their dimensions.

Content
Bases effect model of conveyor machines made for the change of position and orientation; conveyor processes; identification systems; drives; mechanical behaviour of conveyors; structure and function of conveyor machines; elements of intralogistics
sample applications and calculations in addition to the lectures inside practical lectures

Media
supplementary sheets,projector, blackboard

Literature
Recommendations during lessons

Course: Fundamentals of Combustion I [2165515]

Coordinators: U. Maas
Part of the modules: SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

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

Learning Control / Examinations
Compulsory elective subject: Written exam.
In SP 45: oral exam.

Conditions
Can not be combined with lecture 'Fundamentals of Combustion I' [3165016].

Recommendations
Attendance of the tutorial (2165517 - Übungen zu Grundlagen der technischen Verbrennung I)

Learning Outcomes
After completing this course students are able to:

- explain the chemical and physical processes gorverning combustion.
- discuss diagnostic methods apllied in combustion science.
- describe laminar and turbulent flames in a mathematical way.
- analyse the working principle of various technical combustion systems (e. g. piston engines, gas turbines, furnaces).

Content

- Fundamental concepts ans phenomena
- Experimental analysis of flames
- Conservation equations for laminar flat flames
- Chemical reactions
- Chemical kinetics mechanisms
- Laminar premixed flames
- Laminar diffusion flames
- Pollutant formation

Media
Blackboard and Powerpoint presentation

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

Course: Fundamentals of Combustion II [2166538]

Coordinators: U. Maas
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

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

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
Attendance of the tutorial (2166539 - Übung zu Grundlagen der technischen Verbrennung II)

Learning Outcomes
After completing the course attendents are able to:

- explain the processes involved in ignition (auto-ignition and induced ignition).
- describe the governing mechanisms in combustion of liquid and solid fuels.
- understand the mechanisms governing pollutant formation.
- describe turbulent reacting flows by means of simple models.
- explain the occurence of engine knock.
- outline the basic numerical schemes applied in the simulation of reacting flows.

Content

- Three dimensional Navier-Stokes equations for reacting flows
- Tubulent reactive flows
- Turbulent non-premixed flames
- Turbulent premixed flames
- Combustion of liquid and solid fuels
- Engine knock
- Thermodynamics of combustion processes
- Transport phenomena

Media
Blackboard and Powerpoint presentation

Literature
Lecture notes;
Combustion - Physical and Chemical Fundamentals, Modeling and Simulation,Experiments, Pollutant Formation; Authors: U. Maas, J. Warnatz, R.W. Dibble, Springer; Heidelberg, Karlsruhe, Berkley 2006

Course: Optical Flow Measurement: Fundamentals and Applications [2153410]

Coordinators: F. Seiler, B. Frohnapfel
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
none

Learning Outcomes
The students can thoroughly describe the introduced optical measurement techniques. From recently achieve results in shock tunnels, they are able to explain the working principle(s) of the most important registration and visualization methods working with either tracer scattering or with the information obtained with light passing directly the measuring regime. Particularly, the students are qualified to comparatively discuss the measurement techniques for velocity, density and gas temperature (listed below) and can furthermore illustrate their working principles with examples:

- shadowgraph techniques
- Schlieren method
- Mach/Zehnder- and Differential interferometer
- Particle Image Velocimetry (PIV)
- Doppler Global Velocimetry (DGV)
- Doppler picture velocimetry (DPV)
- classical single-beam
- cross-beam anemometry
- interference velocimetry
- CARS-method
- laser-induced fluorescence (LIF)

Content

- Visualisations techniques
- Techniques for local point-wise measurement
- Techniques using light scattering methods
- Laser-induced fluorescence

Literature
H. Oertel sen., H. Oertel jun.: Optische Strömungsmeßtechnik, G. Braun, Karlsruhe

F. Seiler: Skript zur Vorlesung über Optische Strömungsmeßtechnik

Remarks
Block course with limited number of participants, registration in the secretary's office required.
See details at www.istm.kit.edu

Course: Fundamentals for Design of Motor-Vehicles Bodies I [2113814]

Coordinators: H. Bardehle
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Winter term	de

Learning Control / Examinations
Oral group examination

Duration: 30 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students have an overview of the fundamental possibilities for design and manufacture of motor-vehicle bodies. They know the complete process, from the first idea, through the concept to the dimensioned drawings (e.g. with FE-methods). They have knowledge about the fundamentals and their correlations, to be able to analyze and to judge relating components as well as to develop them accordingly.

Content
1. History and design

2. Aerodynamics

3. Design methods (CAD/CAM, FEM)

4. Manufacturing methods of body parts

5. Fastening technologie

6. Body in white / body production, body surface

Literature
1. Automobiltechnische Zeitschrift ATZ, Friedr. Vieweg & Sohn Verlagsges. mbH,
Wiesbaden
2. Automobil Revue, Bern (Schweiz)
3. Automobil Produktion, Verlag Moderne Industrie, Landsberg

Course: Fundamentals for Design of Motor-Vehicles Bodies II [2114840]

Coordinators: H. Bardehle
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
Oral group examination

Duration: 30 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students know that, often the design of seemingly simple detail components can result in the solution of complex problems. They have knowledge in testing procedures of body properties. They have an overview of body parts such as bumpers, window lift mechanism and seats. They understand, as well as, parallel to the normal electrical system, about the electronic side of a motor vehicle. Based on this they are ready to analyze and to judge the relation of these single components. They are also able to contribute competently to complex development tasks by imparted knowledge in project management.

Content
1. Body properties/testing procedures

2. External body-parts

3. Interior trim

4. Compartment air conditioning

5. Electric and electronic features

6. Crash tests

7. Project management aspects, future prospects

Literature
1. Automobiltechnische Zeitschrift ATZ, Friedr. Vieweg & Sohn Verlagsges. mbH, Wiesbaden
2. Automobil Revue, Bern (Schweiz)
3. Automobil Produktion, Verlag Moderne Industrie, Landsberg

Course: Fundamentals in the Development of Commercial Vehicles I [2113812]

Coordinators: J. Zürn
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Winter term	de

Learning Control / Examinations
Oral group examination

Duration: 30 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students have proper knowledge about the process of commercial vehicle development starting from the concept and the underlying original idea to the real design. They know that the customer requirements, the technical realisability, the functionality and the economy are important drivers.
The students are able to develop parts and components. Furthermore they have knowledge about different cab concepts, the interior and the interior design process. Consequently they are ready to analyze and to judge concepts of commercial vehicles as well as to participate competently in the commercial vehicle development.

Content
1. Introduction, definitions, history
2. Development tools
3. Complete vehicle
4. Cab, bodyshell work
5. Cab, interior fitting
6. Alternative drive systems
7. Drive train
8. Drive system diesel engine
9. Intercooled diesel engines

Literature
1. Marwitz, H., Zittel, S.: ACTROS – die neue schwere Lastwagenbaureihe von Mercedes-Benz, ATZ 98, 1996, Nr. 9

2. Alber, P., McKellip, S.: ACTROS – Optimierte passive Sicherheit, ATZ 98, 1996

3. Morschheuser, K.: Airbag im Rahmenfahrzeug, ATZ 97, 1995, S. 450 ff.

Course: Fundamentals in the Development of Commercial Vehicles II [2114844]

Coordinators: J. Zürn
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
Oral group examination

Duration: 30 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students know the advantages and disadvantages of different drives. Furthermore they are familiar with components, such as transfer box, propeller shaft, powered and non-powered frontaxle etc. Beside other mechanical components, such as chassis, axle suspension and braking system, also electric and electronic systems are known. Consequently the student are able to analyze and to judge the general concepts as well as to adjust them precisely with the area of application.

Content
1. Gear boxes of commercial vehicles
2. Intermediate elements of the drive train
3. Axle systems
4. Front axles and driving dynamics
5. Chassis and axle suspension
6. Braking System
7. Systems
8. Excursion

Literature
1. Schittler, M., Heinrich, R., Kerschbaum, W.: Mercedes-Benz Baureihe 500 – neue V-Motorengeneration für schwere Nutzfahrzeuge, MTZ 57 Nr. 9, S. 460 ff., 1996

2. Robert Bosch GmbH (Hrsg.): Bremsanlagen für Kraftfahrzeuge, VDI-Verlag, Düsseldorf, 1. Auflage, 1994

3. Rubi, V., Strifler, P. (Hrsg. Institut für Kraftfahrwesen RWTH Aachen): Industrielle Nutzfahrzeugentwicklung, Schriftenreihe Automobiltechnik, 1993

Course: Fundamentals of Automobile Development I [2113810]

Coordinators: R. Frech
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Winter term	de

Learning Control / Examinations
Written examination

Duration: 90 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students have an overview of the fundamentals of the development of automobiles. They know the development process, the national and the international legal requirements that are to be met. They have knowledge about the thermo-management, aerodynamics and the design of an automobile. They are ready to judge goal conflicts in the field of automobile development and to work out approaches to solving a problem.

Content
1. Process of automobile development
2. Conceptual dimensioning and design of an automobile
3. Laws and regulations – National and international boundary conditions
4. Aero dynamical dimensioning and design of an automobile I
5. Aero dynamical dimensioning and design of an automobile II
6. Thermo-management in the conflict of objectives between styling, aerodynamic and packaging guidelines I
7. Thermo-management in the conflict of objectives between styling, aerodynamic and packaging guidelines II

Literature
The scriptum will be provided during the first lessons

Course: Fundamentals of Automobile Development II [2114842]

Coordinators: R. Frech
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
Written examination

Duration: 90 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture [2114860] "Principles of Whole Vehicle Engineering II".

Recommendations
None.

Learning Outcomes
The students are familiar with the selection of appropriate materials and the choice of adequate production technology. They have knowledge of the acoustical properties of the automobiles, covering both the interior sound and exterior noise. They have an overview of the testing procedures of the automobiles. They know in detail the evaluation of the properties of the complete automobile. They are ready to participate competently in the development process of the complete vehicle.

Content
1. Application-oriented material and production technology I
2. Application-oriented material and production technology II
3. Overall vehicle acoustics in the automobile development
4. Drive train acoustics in the automobile development
5. Testing of the complete vehicle
6. Properties of the complete automobile

Literature
The scriptum will be provided during the first lessons.

Course: High Temperature Materials [2174600]

Coordinators: M. Heilmaier
Part of the modules: SP 56: Advanced Materials Modelling (p. 461)[SP_56_mach]

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

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
none

Recommendations
None

Learning Outcomes
Students are able to

- Define properly the term „high temperature“ with respect to materials
- Describe the shape of the creep curve based on underlying deformation mechanisms
- Rationalize the influence of relevant parameters such as temperature, stress, microstructure on the high temperature deformation behavior
- Develop strategies for improving creep resistance of alloys via modifying their composition
- Select properly industrially relevant high temperature structural materials for various applications

Content

- Phenomenology of High Temperature Deformation
- Deformation Mechanisms
- High Temperature Structural Materials

Literature
M.E. Kassner, Fundamentals of Creep in Metals and Alloys, Elsevier, Amsterdam, 2009

Course: Advanced Methods in Strength of Materials [2161252]

Coordinators: T. Böhlke
Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 25: Lightweight Construction (p. 427)[SP_25_mach]

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

Learning Control / Examinations
depending on choice according to acutal version of study regulations
Additives as announced
Prerequisites have to be met by attestations during the associated lab course

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can

- perform basic tensor operations
- apply solution concepts of elasticity theory to sample problems
- analyse and evaluate systems within the framework of linear elastic fracture mechanics
- know elements of elasto-plasticity theory
- evaluate systems according to known flow and failure hypotheses
- apply concepts of elasto-plasticity to sample problems
- solve independently small problems abot topics of lecture during the corresponding lab course using the FE-software ABAQUS

Content

- kinematics
- mechanical balance laws
- theory of elasticity
- linear elastic fracture mechanics
- linear and plane structures
- elasto-plasticity theory

Literature
lecture notes
Gummert, P.; Reckling, K.-A.: Mechanik. Vieweg 1994.
Gross, D.; Seelig, T.: Bruchmechanik. Springer 2002.
Hibbeler, R.C: Technische Mechanik 2 - Festigkeitslehre. Pearson Studium 2005.

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

Course: Human-oriented Productivity Management: Personnel Management [2109021]

Coordinators: P. Stock
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 28: Lifecycle Engineering (p. 432)[SP_28_mach], SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach]

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

Learning Control / Examinations
Oral exam (ca. 20 minutes)
Compulsory attendance during the whole lecture

Conditions
None.

Recommendations

- Knowledge in Production Management/Industrial Engineering is required
- Knowledge of Work Science and Economics is helpful

Learning Outcomes
The student it capable ...

- to describe and explain the current megatrends, resulting challenges for enterprises as well as operational success factors
- to explain tasks and methods of human-oriented productivity management
- to analyse an existing working system
- to determine the available capacity and the capacity needed of a work system
- to use basic methods and tools of personnel management and to evaluate existing solutions
- to systematically design and organise the employment of staff

Content

1. Introduction: change of the working world, work organisation of successful companies, requirements for Industrial Engineering
2. Human-oriented Productivity Management
3. Organisation of enterprises:
   - Process-oriented work organisation
   - Operational and organisational structure
   - Holistic production systems
4. Basics of personnel management:
   - Identification of available capacity & capacity requirements
   - Management of working time
   - Types of mobile working
5. Systematic design of the human-resource allocation
6. Case study (group work)
7. Presentation of the solutions developed

Media
Powerpoint, exercises, case study

Literature
Handout and literature is available on ILIAS for download.

Remarks

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required

Course: Hybrid and Electric Vehicles [23321]

Coordinators: M. Doppelbauer, M. Schiefer
Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
written exam

Conditions
none

Recommendations
none

Learning Outcomes
The students are able to understand the technical functionality of all drive components of hybrid and electric vehicles and their interaction in the drive train. They possess detailed knowledge about all drive components, in particular batteries and fuel cells, power electronics and electric machines including gears. Moreover they know the different drive train topologies and theirs specific advantages and disadvantages. The students can evaluate the technical, economical and ecological impact of alternative automotive drive technologies.

Content
Starting with the mobility needs of the modern industrialized society and the political goals concerning climate protection, the different drive and charge concepts of battery-electric and hybrid-electric vehicles are introduced and evaluated. The lecture gives a wide overview on all needed components such as electric drive trains, especially batteries, chargers, DC/DC-converters, DC/AC-converters, electrical machines and gear drives.
Structure:
Hybrid automotive drive trains
Electric automotive drive trains
Driving resistance and energy consumption
Control strategies
Energy storage systems
Fundamentals of electric machines
Induction machines
Synchronous machines
Special machines
Power electronics
Charging
Enviroment
Automotive examples
Requirements and specifications

Media
Slides

Literature

- Peter Hofmann: Hybridfahrzeuge – Ein alternatives Antriebskonzept für die Zukunft, Springer-Verlag, 2010
- L. Guzzella, A. Sciarretta: Vehicle Propulsion Systems – Introduction to Modeling and Optimization, Springer Verlag, 2010
- Konrad Reif: Konventioneller Antriebsstrang und Hybridantriebe – Bosch Fachinformation Automobil, Vieweg+Teubner Verlag, 2010
- Rolf Fischer: Elektrische Maschinen, Carl Hanser Verlag München, 2009
- Joachim Specovius: Grundkurs Leistungselektronik, Vieweg+Teubner Verlag, 2010

Remarks

The lecture slides can be downloaded from the institute's homepage at the beginning of the semester. Due to organizational reasons a certificate of attendance cannot be issued.

Course: Hydraulic Fluid Machinery [2157432]

Coordinators: B. Pritz
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	4	Summer term	de

Learning Control / Examinations
Oral or written examination (see anouncement)
No tools or reference materials may be used during the exam.

Conditions
2157432 (Hydraulic Machinery) can not be combined with the event 2157451 (Wind and Hydropower)

Recommendations
2153412 Fluid mechanics

Learning Outcomes
Students get to know the basics of hydraulic fluid machinery (pumps, fans, hydroturbines, windturbines, hydrodynamic transmissions) in general. Application of the knowledge in different fields of engineering.
The lecture introduces the basics of Hydraulic Fluid Machinery. The different types and shapes are presented. The basic equations for the preservation of mass, momentum and energy are discussed. Velocity schemes in typical cascades are shown, the Euler equation of fluid machinery and performance characteristics are deduced.
Similarities and dimensionless parameters are discussed. Fundamental aspects of operation and cavitation are shown.
Students are able to understand the working principle of Hydraulic Fluid Machinery as well as the interaction with typical systems, in which they are integrated.

Content

1. Introduction
2. Basic equations
3. System analysis
4. Elementary Theory (Euler's equation of Fluid Machinery)
5. Operation and Performance Characteristics
6. Similarities, Specific Values
7. Control technics
8. Wind Turbines, Propellers
9. Cavitation
10. Hydrodynamic transmissions and converters

Literature

1. Fister, W.: Fluidenergiemaschinen I & II, Springer-Verlag
2. Bohl, W.: Strömungsmaschinen I & II . Vogel-Verlag
3. Gülich, J.F.: Kreiselpumpen, Springer-Verlag
4. Pfleiderer, C.: Die Kreiselpumpen. Springer-Verlag
5. Carolus, T.: Ventilatoren. Teubner-Verlag
6. Kreiselpumpenlexikon. KSB Aktiengesellschaft
7. Zierep, J., Bühler, K.: Grundzüge der Strömungslehre. Teubner-Verlag

Course: Hydrodynamic Stability: From Order to Chaos [2154437]

Coordinators: A. Class
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
Oral
Duration: 30 minutes
Auxiliary means: none

Conditions
None.

Recommendations
Mathematics

Learning Outcomes
The students can apply the analytic and numerical methods for an evaluation of stability properties of hydrodynamic systems. The are qualified to discuss the characteristic influence of parameter changes (e.g. Renolds number) on the calculated results with respect to the flow character and properties (e.g. transition laminar/turbulent flow).

Content
Increasing a control parameter of a thermohydraulic system, e.g. the Reynolds number, the initial flow pattern (e.g. stationary flow) can be replaced by a different pattern (e.g. turbulent flow).
Typical hydrodynamic instabilities are summarized in the lecture.
The systematic analysis of thermohydraulic stability problems is developed for the case of Rayleigh-Bernard convection (fluid layer heated from below) and selected examples from fluid dynamics.
Covered is:

- linear stability analysis: determine limiting control parameter value up to which the basic flow pattern is stable against small perturbations.
- nonlinear reduced order modeling, capable to characterize more complex flow patterns
- Lorenz system: a generic system exhibiting chaotic behavior

Media
Black board

Literature
Script

Remarks
Lecture also offered as a block-lecture within the AREVA Nuclear Professional School (www.anps.kit.edu)

Course: Industrial aerodynamics [2153425]

Coordinators: T. Breitling, B. Frohnapfel

Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
None.

Learning Outcomes
Students can describe the different challenges of aerdynamical flow that occur in vehicles. They are qualified to analyze external flows around the vehicles, flows in the passenger compartments (thermal comfort), as well as cooling flows, charge motion, mixing and combustion processes in the engine.

Content
This compact lecture deals with flow, mixing and combustion phenomena with significance in vehicle development. A special focus is set on the optimization of external car and truck aerodynamics, thermal comfort in passenger compartments, analyses of cooling flows and improvement of charge motion, mixing and combustion in piston engines. These fields are explained in their phenomenology, the corresponding theories are discussed and the tools for measurement and simulation are introduced and demonstrated. The focus of this lecture is on industry relevant methods for analyses and description of forces, flow structures, turbulence, flows with heat transfer and phase transition and reactive flows. In addition an introduction to modern methods in accuracy control and efficiency improvement of numerical methods for industrial use is given. The integration and interconnection of the methods in the development processes are discussed examplary.
An excursion to the Daimler AG wind tunnel (aeroacoustic wind tunnel, climate wind tunnel, thermal measurements) and the research and development centers is offered.

- Introduction
- Industrial flow measurement techniques
- Flow simulation and control of numerical errors, turbulence modeling
- Cooling flows
- Flow mixing and combustation at direct injected Diesel engines
- Flow mixing and combustation at gasoline engine
- Vehicle aerodynamics
- HVAC-Systems and thermal comfort

Literature
Script

Remarks
Block course with limited number of participants, registration in the secretary's office required. See details at www.istm.kit.edu

Course: Introduction to Industrial Production Economics [2109042]

Coordinators: S. Dürrschnabel
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 28: Lifecycle Engineering (p. 432)[SP_28_mach], SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach]

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

Learning Control / Examinations
Elective Subject: oral exam (approx. 30 min)
The exam is offered in German only!

Conditions
Registration for the lecture via ILIAS is required.

Learning Outcomes

- The students know the possible organisational structures for enterprises.
- The students learn about the importance of process data as basis for efficient work structuring.
- The students are able to execute and evaluate time studies in industry (e. g. REFA).
- The students know different methods for the evaluation of workplaces.
- The students know basic techniques for the determination of wages.
- The students are able to make a cost calculation for a specific product.

Content

- Design of structural and process organisation
- Execution and evaluation of time studies
- Actual tools for time studies, e.g. Work Sampling, Methods-Time Measurement, Planned times,
- Evaluation of workplaces and determination of wages
- Cost accounting (including process costs)

Literature

Handout and literature are available on ILIAS for download.

Course: Occupational Safety and Environmental Protection (in German) [2110037]

Coordinators: R. von Kiparski
Part of the modules: SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach]

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

Learning Control / Examinations
Elective Subject: oral exam (approx. 30 min)
Optional Subject: oral exam (approx. 30 min)
The exam is offered in German only!

Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required
- Compulsory attendance during the whole lecture

Recommendations

- Knowledge of Human Factors Engineering is helpful

Learning Outcomes
The participant can

- explain the importance of occupational safety and environmental protection as well as their connection to each other.
- describe the influence of human behaviour in this context.
- explain the possibilities and limits for an engineer in this context.
- realise, wether the professional assistance of an expert of other faculties is needed.
- work through the case studies in small groups.
- evaluate and present the results of his/her work.

Content
The participants have to solve a specific case study within the field of occupational safety and environmental protection. Therefore, they work in a team. The course work covers the information research as well as the presentation of the results.

Content:

- Occupational Safety and Safety Engineering
- Environmental Protection within a Production Enterprise
- Health Management

Structure:

- Terminology
- Basics of Occupational Safety and Environmental Protection

- Case Study
- Moderated Processing of a Case Stuy within a Small Group

Literature
Handout and literature are available on ILIAS for download.

Course: Information Engineering [2122014]

Coordinators: J. Ovtcharova
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	

Learning Control / Examinations
Non exam assessment (following §4(2), 3 of the examination regulation).

Conditions
None.

Learning Outcomes
Students

- explain basic knowledge and concepts in a subarea of “Information Engineering”,

- apply methods and instruments in a subarea of “Information Engineering”,

- choose the appropriate methods to solve given problems and apply them,

- find and discuss the achieved solution approaches.

Content
Practical seminars on current research topics of the institute in the fields of Lifecycle Engineering, Knowledge Management, Smart Immersive Environments and Industrie 4.0 .

Course: Information Systems in Logistics and Supply Chain Management [2118094]

Coordinators: C. Kilger
Part of the modules: SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach], SP 19: Information Technology of Logistic Systems (p. 420)[SP_19_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 18: Information Technology (p. 419)[SP_18_mach]

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

Learning Control / Examinations
oral / written (if necessary)

Conditions
none

Recommendations
none

Learning Outcomes
Students are able to:

- Describe requirements of logistical processes regarding IT systems,
- Choose information systems to support logistical processes and use them according to the requirements of a supply chain.

Content
1) Overview of logistics systems and processes
2) Basic concepts of information systems and information technology
3) Introduction to IS in logistics: Overview and applications
4) Detailed discussion of selected SAP modules for logistics support

Media
presentations

Literature
Stadtler, Kilger: Supply Chain Management and Advanced Planning, Springer, 4. Auflage 2008

Remarks
none

Course: Information Processing in Mechatronic Systems [2105022]

Coordinators: M. Kaufmann
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 18: Information Technology (p. 419)[SP_18_mach]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Basic knowledge of computer science and programming

Learning Outcomes
Students have fundamental knowledge about selection, conceptual design and development of information processing components in mechatronic systems.

Content
Information processing components – consisting of sensors, actors, hardware and software – are of essential importance for the implementation of mechatronic functions.
Based on requirements on information processing in mechatronic systems typical hardware and software solutions are examined. Characteristics, advantages, disadvantages and application areas are discussed. Solutions are examined regarding real-time capabilities, dependability, safety and fault tolerance. Bus communication in mechatronic systems is examined. Description methods and several approaches of functional description are considered. An approach on the development of information processing components is developed. Lecture topics are complemented by practical examples.
Outline:

- Requirements on information processing components,
- Characteristics of information processing components
- Real-time capabilities, dependability, safety and fault tolerance
- Architectures of information processing components
- Communication in mechatronic systems
- Descriptive models und functional description
- Development of information processing components

Software quality

Literature

- Marwedel, P.: Eingebettete Systeme. Springer: 2007.
- Teich, J: Digitale Hard-, Software-Systeme. Springer: 2007.
- Wörn, H., Brinkschulte, U.: Echtzeitsysteme: Grundlagen, Funktionsweisen, Anwendungen. Springer, 2005.
- Zöbel, D.: Echtzeitsysteme: Grundlagen der Planung. Springer, 2008.

Course: Information Processing in Sensor Networks [24102]

Coordinators: U. Hanebeck, Christiof Chlebek
Part of the modules: SP 18: Information Technology (p. 419)[SP_18_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach]

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

Learning Control / Examinations
The assessment is explained in the module description.

Conditions
None.

Recommendations
Knowledge of the lectures *Localization of Mobile Agents* [IN4INLMA] or *Stochastic Information Processing* [IN4INSIV] will be beneficial.

Learning Outcomes
The student understands the specific challenges of information processing in the area of sensor networks and become acquainted with the different levels of processing procedures for the sensor measurements. The student is able to analyze, compare, and evaluate different approaches towards information processing in sensor networks.

Content
In the lecture, relevant aspects of information processing in sensor networks are considered. First, the technical configuration of a single sensor node is presented. This includes the main components required for information processing, like sensor technology, analog signal processing, analog-to-digital conversion, and digital signal processing. In the second part, approaches for localization, time synchronization, routing, and sensor scheduling are presented. At the end of the lecture, approaches for sensor information fusion as well as the model-based reconstruction of distributed phenomena are discussed.

Media

- Handwritten lecture notes will be made available electronically.
- Figures and application examples on slides.

More information can be retrieved from the information brochure available on the ISAS website.

Literature
Elective literature:
Lecture notes

Course: Innovative Nuclear Systems [2130973]

Coordinators: X. Cheng
Part of the modules: SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 21: Nuclear Energy (p. 422)[SP_21_mach]

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

Learning Control / Examinations

- oral examination
- duration 20min

Conditions
None.

Learning Outcomes
This lecture is addressed to students of mechanical engineering, chemical engineering and physics. Goal of the lecture is the explanation of state-of-the-art development of nuclear systems. Nuclear systems, that are from todays point of view promising will be presented and explained. The main characteristics of such systems and the associated challenges are also part of the lecture.

Content

1. state of the art and development tendencies in nuclear systems
2. advanced concepts in light water cooled systems
3. new developments in fast reactors
4. development tendencies in gas-cooled plants
5. transmutation systems for waste management
6. fusionsystems

Course: Innovative Project [2169466]

Coordinators: A. Class, Prof. Dr. O. Terzidis
Part of the modules: SP 59: Innovation and Entrepreneurship (p. 464)[SP_59_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Winter term	en

Learning Control / Examinations
Students have to deliver pitch-talk supported by slides to convience a commity about their results. A fictive project proposal of 10 to 15 pages.

Conditions
None.

Recommendations
Proof of English proficiency by a test:
IELTS Academic test
An overall band score of at least 6.5 (with no section lower than 5.5)
University of Cambridge
Certificate in Advanced English, CAE (grades A – C)
Certificate of Proficiency in English, CPE (grades A – C)
TOEFL Internet-based test, IBT

Learning Outcomes
- Understand the physics of the technology of the invention considered in the project
- Understand the claims of the patent considered in the project
- Apply a structured technology application selection methodology.
- Student understand the methodology of TAS, which provides the background to become a TAS coach.
- Students are enabled to prepare a proposal for funding.

Content
The TAS (technology application selection) methodology provides tools that help to successfully advance an invention with a low technology readiness level to a higher technology readiness level. Skills that are typically provided by a classical engineering education supports both the early phase of an invention where a deep basic understanding is required and the industrial exploration building on a first prototype. The gap that arises between the invention and its later industrialized application is rarely addressed, so that many inventions will not make it to the market. In the course, we practice bridging the technology gap for the case of a real invention provided by an industry partner or University. We experiment with teams consisting of team members located at different universities and from different disciplines.
The scenario addressed is an inventor who calls some of his friends within her/his personal network. The group will work remotely via video conference employing a structured TAS process. Creativity will be fertilized by teamwork and linking the invention to a selection of potential technologies. In an in-depth analysis of these links, each group narrows down their pool of ideas to one candidate. Finally, the group will try to convince the fellow teams (and the inventor) to support their idea. For this purpose, a pitch talk is prepared and delivered in front of all teams leading to a unique vote of all teams for one technology application. In addition the students prepare fictive proposals for start-up based on their TAS.

Media
own laptop and skype

Remarks
The subject of the project is provided by industry partner or the innovation department from KIT or INP Grenoble. Representatives of industry partner will be

addressee for the pitch-talk. Teams of 2-3 students.

Course: Integrative Strategies in Production and Development of High Performance Cars [2150601]

Coordinators: K. Schlichtenmayer
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
The assessment is carried out as an written exam.

Conditions
None

Learning Outcomes
The students . . .

- are capable to specify the current technological and social challenges in automotive industry.
- are qualified to identify interlinkages between development processes and production systems.
- are able to explain challenges and solutions of global markets and global production of premium products.
- are able to explain modern methods to identify key competences of producing companies.

Content
The lecture deals with the technical and organizational aspects of integrated development and production of sports cars on the example of Porsche AG. The lecture begins with an introduction and discussion of social trends. The deepening of standardized development processes in the automotive practice and current development strategies follow. The management of complex development projects is a first focus of the lecture. The complex interlinkage between development, production and purchasing are a second focus. Methods of analysis of technological core competencies complement the lecture. The course is strongly oriented towards the practice and is provided with many current examples.
The main topics are:

- Introduction to social trends towards high performance cars
- Automotive Production Processes
- Integrative R&D strategies and holistic capacity management
- Management of complex projects
- Interlinkage between R&D, production and purchasing
- The modern role of manufacturing from a R&D perspective
- Global R&D and production
- Methods to identify core competencies

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Slides

Course: Integrated Product Development [2145156]

Coordinators: A. Albers
Part of the modules: SP 20: Integrated Product Development (p. 421)[SP_20_mach]

ECTS Credits	Hours per week	Term	Instruction language
16	8	Winter term	de

Learning Control / Examinations
oral examination (60 minutes)
combined examination of lectures, tutorials and project work

Conditions
The participation in "Integrated Product Development" requires the concurrent participation in lectures (2145156), tutorials (2145157) and project work (2145300).
Due to organizational reasons, the number of participants is limited. Thus a selection has to be made. For registration to the selection process a standard form has to be used, that can be downloaded from IPEK hompage from april to july. The selection itself is made by Prof. Albers in personal interviews.

Recommendations
none

Learning Outcomes
The Students are able to ...

- analyze and evaluate product development processes based on examples and their own experiences.
- plan, control and evaluate the working process systematically.
- choose and use suitable methods of product development, system analysis and innovation management under consideration of the particular situation.
- prove their results.
- develop complex technical solutions in a team and to present them to qualified persons as well as non-qualified persons
- to design overall product development processes under consideration of market-, customer- and company-aspects

Content
organizational integration: integrated product engineering model, core team management and simultaneous engineering
informational integration: innovation management, cost management, quality management and knowledge management
personal integration: team coaching and leadership management
invited lectures

Literature
Klaus Ehrlenspiel - Integrierte Produktentwicklung. Denkabläufe, Methodeneinsatz, Zusammenarbeit, Hanser Verlag, 2009

Remarks
The lecture starts in first week of October.

Course: Integrated Production Planning in the Age of Industry 4.0 [2150660]

Coordinators: G. Lanza
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	6	Summer term	de

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students . . .

- can discuss basic questions of production technology.
- are able to apply the methods of integrated production planning they have learned about to new problems.
- are able to analyze and evaluate the suitability of the methods, procedures and techniques they have learned about for a specific problem.
- can apply the learned methods of integrated production planning to new problems.
- can use their knowledge targeted for efficient production technology.

Content
Integrated production planning in the age of industry 4.0 will be taught in the context of this engineering science lecture. In addition to a comprehensive introduction to Industry 4.0, the following topics will be addressed at the beginning of the lecture:

- Basics, history and temporal development of production
- Integrated production planning and integrated digital engineering
- Principles of integrated production systems and further development with Industry 4.0

Building on this, the phases of integrated production planning are taught in accordance with VDI Guideline 5200, whereby special features of parts production and assembly are dealt with in the context of case studies:

- Factory planning system
- Definition of objectives
- Data collection and analysis
- Concept planning (structural development, structural dimensioning and rough layout)
- Detailed planning (production planning and control, fine layout, IT systems in an industry 4.0 factory)
- Preparation and monitoring of implementation
- Start-up and series support

The lecture contents are rounded off by numerous current practical examples with a strong industry 4.0 reference. Within the exercises the lecture contents are deepened and applied to specific problems and tasks.

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Course: Introduction to Neutron Cross Section Theory and Nuclear Data Generation [2190490]

Coordinators: R. Dagan
Part of the modules: SP 21: Nuclear Energy (p. 422)[SP_21_mach]

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

Learning Control / Examinations
oral exam, 30 min.

Conditions
none

Recommendations
none

Learning Outcomes
The students:

- Understand the special importance of cross sections in various domains of natural science (Reactor physics, Material research, Solar radiation etc.)
- Are familiar with the theoretical methods and experimental effort to generate cross sections data.

Content
Cross section characterization
Summary of basic cross section theory
Resonance cross section
Doppler broadening
Scattering kernels
Basic of slowing down theory
Unit cell based XS data generation
Cross sections Data libraries
Data Measurements

Literature
Handbook of Nuclear Reactors Calculations Vol. I Y. Ronen, CRC Press 1986
D. Emendorfer. K.H. Höcker Theory of nuclear reactions, Parts I, II BI- Hochschultaschenbücher 1969 (in German)
P. Tippler, R. Llewellyn Modern Physics 2008

Course: IoT platform for engineering [2123352]

Coordinators: J. Ovtcharova, T. Maier
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

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

Learning Control / Examinations
Assessment of another type (graded), procedure see webpage. Number of participants limited to 20 people. There is a participant selection process.

Conditions
None.

Learning Outcomes

- In context of I4.0 students are able to represent and analyze processes using specialized methods of process management.
- Teams of students are able to understand practice-relevant I4.0 issues concerning existing hard- and software and discuss and provide proposals for a continuous improvement process.
- Student teams can also provide prototypically implementation of the obtained solutions using given IT systems and equipment and present the final results.

Content
Industry 4.0, IT systems for fabrication and assembly, process modelling and execution, project work in teams, practice-relevant I4.0 problems, in automation, manufacturing industry and service.

Remarks
Number of participants limited to 20 people. There is a participant selection process.

Course: IT-Fundamentals of Logistics [2118183]

Coordinators: F. Thomas

Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 19: Information Technology of Logistic Systems (p. 420)[SP_19_mach]

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

Learning Control / Examinations
oral / written (if necessary)
examination aids: none

Conditions
None.

Recommendations
None.

Learning Outcomes
Students are able to:

- Describe and classify automation technology for material flow and the information technology necessary,
- identify, analyze and design the business processes in internal logistics,
- identify risks of failure and counteract and
- transfer the knowledge to practical implementations.

Content
This lecture, with exercises, treats automation technology in material flow as well as the information technology that has a direct relationship with it. In the first few chapters and exercises, an overview is given of the motors and conveying technology elements used in materials handling, and the sensors required for the purpose are explained. The target control types as well as the topic of coding techniques and RFID (GS1, barcodes, scanner, etc.) are treated in detail. Material flow controls are defined based on these chapters. Among other things, the functions of a stored-memory controller are explained in this section. Hierarchically classified control structures and
their integration in network structures are considered in detail. The principles of communications systems (bus systems etc.) are supplemented with information on the use of the Internet as well as data warehousing strategies. An overview of modern logistics systems, especially in stores administration, illustrates new problem solution strategies in the area of information technology for logistics systems. After an analysis of the causes for system failures, measures are worked
out for reducing the risks of failure. Furthermore, the objectives, task areas as well as various scheduling strategies in the area of transport management and control are presented. Worthwhile information on Europe-wide logistics concepts round off this practice-oriented lecture series. The presentation of the lectures will be multimedia-based. Exercises repeat and extend the knowledge principles imparted in the lectures and illustrate the
subject with practical examples.
Focuses:

- System architecture for logistics solutions / Modularization of conveyors
- Material Flow Control System (MFCS) / Transport Handling
- GS 1, optical reading systems, RFID
- Data communication between controllers, computers and networks
- Business processes for internal logistics – software follows function

- Adaptive IT - Future-oriented software architecture
- System stability and data backup –Software-Engineering

Literature
Detailed script can be downloaded online (www.tup.com), updated and enhanced regularly.

Course: Introduction to Ceramics [2125757]

Coordinators: M. Hoffmann
Part of the modules: SP 43: Technical Ceramics and Powder Materials (p. 449)[SP_43_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
The assessment consists of an oral exam (30 min) taking place at a specific date.
The re-examination is offered at a specific date.

Conditions
none

Recommendations
Fundamentals in natural science are recommended for students in mechanical and industrial engineering. The lecture requires the basics of the material science courses in mechanical or industrial engineering for bachelor students.

Learning Outcomes
The students know the most relevant crystal structures and defects of non metallic inorganic materials, are able to read binary and ternary phase diagrams and are familar with powdertechnological shaping techniques, sintering and grain growth. They know the basics of the linear elastic fracture mechanics, are familar with Weibull statistics, K-concept, subcritical crack growth, creep and the opportunities for microstructural reinforcement of ceramics. The students are able to explain the correlation among chemical bonding, crystal and defect structures and the electrical properties of ceramics.

Content
After a short introduction to interatomic bonding, fundamental concepts of crystallography, the stereographic projection and the most important symmetry elements will be given. Different types of crystal structures are explained and the relevance of imperfections are analysed with respect to the mechanical and electrical properties of ceramics. Then, the impact of surfaces, interfaces and grain boundaries for the preparation, microstructural evolution and the resulting properties is discussed. Finally, an introduction is given to ternary phase diagrams.
The second part of the course covers structure, preparation and application aspects of nonmetallic inorganic glasses, followed by an introduction to the properties and processing methods of fine-grained technical powders. The most relevant shaping methods, such as pressing, slip casting, injection moulding and extrusion are introduced. Subsequently, the basics of science of sintering and the mechanisms for normal and abnormal grain growth are discussed. Mechanical properties of ceramics are analysed using basic principles of linear elastic fracture mechanics, Weibull statistics, concepts for subcritical crack growth and creep models to explain the behaviour at elevated temperatures. Furthermore it is demonstrated that mechanical properties can be siginificantly enhanced by various types of microstructural toughening mechanisms. The electronic and ionic conductivity of ceramic materials are explained based on defect-chemical considerations and band structure models. Finally, the characteristics of a dielectric, pyroelectric, and piezoelectric behaviour is discussed.

Media
Slides for the lecture:
available under http://ilias.studium.kit.edu

Literature

- H. Salmang, H. Scholze, “Keramik“, Springer
- Kingery, Bowen, Uhlmann, “Introduction To Ceramics“, Wiley
- Y.-M. Chiang, D. Birnie III and W.D. Kingery, “Physical Ceramics”, Wiley
- S.J.L. Kang, “Sintering, Densification, Grain Growth & Microstructure”, Elsevier

Course: Ceramic Matrix Composites [2126810]

Coordinators: D. Koch
Part of the modules: SP 43: Technical Ceramics and Powder Materials (p. 449)[SP_43_mach]

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

Learning Control / Examinations
The assessment consists of an oral exam (20-30 min) taking place at the agreed date. The re-examination is offered upon agreement.

Conditions
none

Recommendations
Knowledge of basic material science is assumed.

Learning Outcomes
The students know the basics of the complete processing chain from manufacture of ceramic matrix composites (CMC) to design and application of CMC. They are able to assess the conditions for applying CMC. They have knowledge on production, properties and application. They are able to correlate the microstructural properties and specialities with macroscopic behavior of CMC and CMC components.

Content
The lecture gives an overview on production, properties and application of fiber reinforced ceramic matrix composites (CMC). CMC are suitable for application at high temperatures, under corrosive atmosphere and under complex laoding conditions. In the lecture we will learn the complete processing chain from raw materials as fibers and matrices to the components for e.g. gas turbines, reentry vehicles, heat exchangers. The microstructural influence on the macrostructural behavior of components will be discussed.

Media
Slides for the lecture: available under http://ilias.studium.kit.edu

Literature

- N.P. Bansal, J. Lamon,Ceramic Matrix Composites: Materials, Modeling and Technology.John Wiley & Sons, Inc., 2015.
- W. Krenkel,Ceramic Matrix Composites.Wiley-VCH Verlag GmbH & Co. KGaA, 2008.
- K. K. Chawla,Ceramic Matrix Composites. 2nd ed., Kluwer Academic Publishers, 2003.

Course: Ceramics Processing [2126730]

Coordinators: J. Binder
Part of the modules: SP 43: Technical Ceramics and Powder Materials (p. 449)[SP_43_mach]

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

Learning Control / Examinations
The assessment consists of an oral exam (approx. 20 min) taking place at the agreed date.
Auxiliary means: none
The re-examination is offered upon agreement.

Conditions
none

Recommendations
Basics of the course “Introduction to Ceramics” should be known.

Learning Outcomes
The students are able to name the major ceramic process technologies and explain their specifics in detail. Additionally, they are capable of illustrating the correlations between the individual processes and their importance for the production of engineering ceramics. The students are able to relate processing effects to material properties. Furthermore the students can apply the basics to concrete tasks. They are able to comprehend and assess information in professional articles.

Content
The course imparts technological basics for processing of engineering ceramics. The course is arranged in the following units:

- Synthesis methods
- Powder conditioning and mixing methods
- Forming of ceramics
- Sintering
- Finishing processes
- Ceramic films and multi-layer systems
- Effects of processing on properties

Literature
W. Kollenberg: Technische Keramik, Vulkan Verlag 2010.
M. N. Rahaman: Ceramic Processing, CRC Taylor & Francis, 2007.
D.W. Richerson: Modern ceramic engineering, CRC Taylor & Francis, 2006.
A. G. King: Ceramic Technology and Processing, William Andrew, 2002.

Course: Nuclear Power Plant Technology [2170460]

Coordinators: T. Schulenberg, K. Litfin
Part of the modules: SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 21: Nuclear Energy (p. 422)[SP_21_mach]

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

Learning Control / Examinations
oral examination
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Knowledge of thermodynamics are a mandatory requirement for this course.
Basic knowledge of the physics of nuclear fission wiill be helpful.
Simulator exercises with a simplified pressurized water reactor and a simplified boiling water reactor are offered to ease understanding of thermodynamics and neutron physics.

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in nuclear power plant engineering. The participants can describe the most important components of nuclear power plants and their function. You can design or modify nuclear power plants independently and creatively. They have acquired a broad knowledge of this power plant technology, including specific knowledge of core design, design of primary and secondary systems, and of nuclear safety technologies. Based on the acquired knowledge in thermodynamics and neutron physics, they can describe and analyze the specific behavior of the nuclear power plant components and assess risks. Participants of the lecture have a trained analytical thinking and judgment in the design of nuclear power plants.

Content
Power plants with pressurized water reactors:
Design of the pressurized water reactor

- Fuel assemblies
- Control rods and drives
- Core instrumentation
- Reactor pressure vessel and its internals

Components of the primary system

- Primary coolant pumps
- Pressurizer
- Steam generator
- Water make-up system

Secondary system:

- Turbines
- Reheater
- Feedwater system

- Cooling systems

Containment

- Containment design
- Components of safety systems
- Components of residual heat removal systems

Control of a nuclear power plant with PWR
Power plants with boiling water reactors:
Design of the boiling water reactor

- Fuel assemblies
- Control elements and drives
- Reactor pressure vessel and its internals

Containment and components of safety systems
Control of a nuclear power plant with boiling water reactors

Media
Powerpoint presentations
PWR simulator
BWR simulator

Literature
lecture notes

Course: Cogitive Automobiles - Laboratory [2138341]

Coordinators: C. Stiller, M. Lauer
Part of the modules: SP 40: Robotics (p. 445)[SP_40_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	de

Learning Control / Examinations
oral exam

Conditions
None.

Recommendations
The participants should have knowledge from one or several of the lectures “machine vision”, “automotive vision”, or “behavior generation for vehicles” or attend one of these lectures in parallel. Furthermore, they must have basic knowledge in programing.

Learning Outcomes
The lab offers the possibility to implement the techniques from the lectures „automotive vision“ and „behavior generation for automobiles“ in groups of 4-5 students. The task is to implement the environment perception and control of a model car such that the car is able to drive autonomously on a predefined course. Each group manages itself, selects the relevant techniques, implements it in the programing language C++, and tests it on the model car. It presents its approach in three presentations. At the end of the lab, the approaches of the groups are compared in a competition.
Goal of the lab is to get hands-on experience in the fields of camera based environment perception, control of autonomous cars, sensor data analysis, and programing. Furthermore, the lab supports experiences in the management of a project, teamwork, software engineering, literature research, and presentation techniques.

Content
1. road recognition
2. obstacle detection
3. trajectory planning
4. vehicle control

Literature
Documentation of the software and hardware will be provided as pdf file.

Remarks
The number of participants is limited. A registration is mandatory, the details are announced on the webpages of the institute of measurement and control systems (mrt). In case of too many interested students a subset will be selected (see website).

Course: Cognitive Systems [24572]

Coordinators: R. Dillmann, A. Waibel
Part of the modules: SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	de

Learning Control / Examinations

Conditions
None.

Recommendations
Basic knowledge in informatics is helpful.

Learning Outcomes

- The relevant elements of technical cognitive systems can be named and their tasks can be described.
- The problems in the relevant areas can be recognized and processed.
- Further approaches and methods can be exploited autonomously and applied successfully.
- Variations of the problems can be solved successfully.
- The educational objectives shall be achieved by visiting the complementary tutorials.

The students know the basic concepts and methods of image representation and processing, e.g. homogenous point operations, histogram analysis and image filters. They are able to explain and assess methods for segmenting image data based on threshold, colour, edges and point features. They understand the properties of stereo camera systems, e.g. epipolar geometry and triangulation for 3D reconstruction. They are proficient in propositional logic and predicate logic. They know planning languages and different algorithms for path planning as well as models for representation of objects and numerical representations of robots.
The students will be able to handle the fundamental steps of signal processing and can list their advantages and disadvantages. Given a certain problem, they will be able to select the appropriate signal processing steps. The students will be able to work with the taxonomie of classification systems and are able to classify methods in terms of the taxonomie. Students shall be able to give examples for every class in the taxonomie. Students shall be able to build simple naïve Bayes classifiers and to analyse them with respect to error probability.
Students shall be able to name the fundamental terms of machine learning, as well as to be familiar with the basic methods of machine learning. Students shall be familiar with the principles of a multi layer perceptron and to be able to handle the basics of back-propagation training. Further, they shall be able to name and describe further types of neural networks. The students will be able to describe the basic design of a statistical speech recognition system for large vocabulary speech recognition. They shall be able design simple models for automatic speech recognition and to estimate their parameters. They shall further be able to conduct a simple pre-processing for speech recognition. They also shall be able to work with the fundamental error measures of speech recognition and to calculate them.

Content
Cognitive systems act on the basis of perception and knowledge. After reception of stimuli through receptors, the signals are processed, and based on a knowledge base actions are triggered. In the lecture, the involved modules of a cognitive system are presented. To these belong in addition to acquisition and processing of environmental information (e.g. images, speech), the representation of knowledge as well as the assignment of features with the aid of classifiers. Further core themes of the lecture will be learning and planning methods, and their implementation. The presented methods and approaches will be deepened in the tutorials by means of exercises.

Media
Slides, lecture notes (available for download)

Literature
„Artificial Intelligence – A Modern Approach“, Russel, S.; Norvig, P.; Prentice Hall. ISBN 3895761656.

Elective literature:
„Computer Vision – Das Praxisbuch“, Azad, P.; Gockel, T.; Dillmann, R.; Elektor-Verlag. ISBN 0131038052.
“Discrete-Time Signal Processing”, Oppenheim, Alan V.; Schafer, Roland W.; Buck, John R.; Pearson US Imports & PHIPEs. ISBN 0130834432.
“Signale und Systeme”, Kiencke, Uwe; Jäkel, Holger; Oldenbourg, ISBN 3486578111.

Course: Design with Plastics [2174571]

Coordinators: M. Liedel
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 36: Polymer Engineering (p. 442)[SP_36_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach], SP 10: Engineering Design (p. 412)[SP_10_mach]

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

Learning Control / Examinations
Oral exam, about 20 minutes

Conditions
none

Recommendations
'Polymer Engineering I'

Learning Outcomes
Students will be able to
• distinguish polymer compounds from other construction materials regarding chemical differences, thermal behavior and solid conditions.
• discuss main plastics processes regarding advantages and disadvantages of materials selection and part geometry design and to make appropriate selections.
• analyze complex application requirements concerning material impacts on strength and to use the classic dimensioning method specific to the application to evaluate the lifetime part strength limit.
• evaluate part tolerances and geometry by appropriate methods considering molding shrinkage, production tolerances, post shrinkage, heat expansion, swelling, elastic and creep deformation.
• design plastic specific joining geometries like snap fits, screw bosses, weld seams and film hinges.
• detect classic molding failures and understand potential causes as well as to reduce the probability of molding failures by defining an optimized design.
• understand benefits and limits of selected simulation tools in the plastic technology discipline (strength, deformation, filling, warpage).
• assess polymer classes and plastic part designs with respect to suitable recycling concepts and ecological consequences.

Content
Structure and properties of plastics materials,
Processing of plastics,
Behavior of plastics under environmental impacts,
Classic strength dimensioning,
Geometric dimensioning,
Plastic appropriate design,
Failure examples,
Joining of plastic parts,
Supporting simulation tools,
Structural foams,
Plastics Technology trends.

Literature
Scriptum will be handed out during the lecture.
Recommended literature are provided in the lecture.

Course: Lightweight Engineering Design [2146190]

Coordinators: A. Albers, N. Burkardt

Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
The type of examination (written or oral) will be announced at the beginning of the lecture.
written examination: 90 min duration
oral examination: 20 min duration
Auxiliary means: none.

Conditions
none

Learning Outcomes
The students are able to ...

- evaluate the potential of central lightweight strategies and their application in design processes.
- apply different stiffing methods qualitatively and to evaluate their effectiveness.
- evaluate the potential of computer-aided engineering as well as the related limits and influences on manufacturing.
- reflect the basics of lightweight construction from a system view in the context of the product engineering process.

Content
General aspects of leightweight design, lightweight strategies, construction methods, design principles, lightweight construction, stiffening techniques, lightweight materials, virtual product engineering, bionics, joining techniques, validation, recycling
Additionally, guest speakers from industry will present lightweight design from an practical point of view.

Media
Beamer

Literature
Klein, B.: Leichtbau-Konstruktion. Vieweg & Sohn Verlag, 2007
Wiedemann, J.: Leichtbau: Elemente und Konstruktion, Springer Verlag, 2006
Harzheim, L.: Strukturoptimierung. Grundlagen und Anwendungen. Verlag Harri Deutsch, 2008

Remarks
Lecture slides are available via eLearning-Platform ILIAS.

Course: Contact Mechanics [2181220]

Coordinators: C. Greiner
Part of the modules: SP 47: Tribology (p. 453)[SP_47_mach]

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

Learning Control / Examinations
oral exam ca. 30 minutes

Conditions
none

Recommendations
preliminary knowledge in mathematics, physics and materials science

Learning Outcomes
The student

- knows models for smooth and rough surfaces under non-adhesive and adhesive conditions and understands their strengths and limits
- knows fundamental scaling relations for the functional dependency between contact area, stiffness and normal force
- can apply numerical methods to study questions from materials science

Content
The course introduces contact mechanics of smooth and rough surface for non-adhesive and adhesive interfacial conditions. There will a computer lab held in parallel to the lecture that teaches numerical approaches to contact mechanical problems.

1. Introduction: contact area and stiffness
2. Theory of the elastic half-space
3. Contact of nonadhesive spheres: Hertz theory
4. Physics and chemistry of adhesive interactions at interfaces
5. Contact of adhesive spheres: theories of Johnson-Kendall-Roberts, Derjaguin-Muller-Toporov and Maugis-Dugdale
6. Surface roughness: topography, power spectral density, structure of real surfaces, fractal surfaces as a model, metrology
7. Contact of nonadhesive rough surfaces: theories of Greenwood-Williamson, Persson, Hyun-Pei-Robbins-Molinari
8. Contact of adhesive rough surface: theories of Fuller-Tabor, Persson and recent numerical results
9. Contact of rough spheres: theory of Greenwood-Tripp and recent numerical results
10. Lateral and sliding contact: theories of Cattaneo-Mindlin, Savkoor, Persson
11. Applications of contact mechanics

Exercises are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students.

Media
lecture notes via ILIAS

Literature
K. L. Johnson, Contact Mechanics (Cambridge University Press, 1985)
D. Maugis, Contact, Adhesion and Rupture of Elastic Solids (Springer-Verlag, 2000)
J. Israelachvili, Intermolecular and Surface Forces (Academic Press, 1985)

Course: Motor Vehicle Laboratory [2115808]

Coordinators: M. Frey
Part of the modules: SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
Colloquium before each experiment
After completion of the experiments: written examination
Duration: 90 minutes
Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students have deepened their knowledge on motor vehicles acquired in lectures and can apply it practically. They have an overview of the applied measuring technique and can execute and analyse measurements for the handling of given problem definitions. They are ready to analyze and to judge measurement results.

Content
1. Determination of the driving resistances of a passenger vehicle on a roller dynamometer; measurement of the engine performance of the test vehicle

2. Investigation of a twin-tube and a single-tube shock absorber

3. Behavior of car tyres under longitudinal forces and lateral forces

4. Behavior of car tires on wet road surface

5. Rolling resistance, energy dissipation and high-speed strength of car tires

6. Investigation of the moment transient characteristic of a Visco clutch

Literature
1. Matschinsky, W: Radführungen der Straßenfahrzeuge, Verlag TÜV Rheinland, 1998

2. Reimpell, J.: Fahrwerktechnik: Fahrzeugmechanik, Vogel Verlag, 1992

3. Gnadler, R.: Documents to the Motor Vehicle Laboratory

Remarks
The admission is limited to 12 persons per group.

Course: Cooling of thermally high loaded gas turbine components [2170463]

Coordinators: H. Bauer, A. Schulz
Part of the modules: SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes
The students are able to:

- name and differentiate beween different cooling methods and analyse them
- judge on the advantages and disadvantages of cooling methods and discuss approaches for the improvement of complex cooling methods
- to outline the basics of forces convectice heat transfer and film cooling
- design colled gas turbine components in a simplified manner
- comment on the experimental and numerical methods for the characterisation of heat transfer

Content
Hot gas temperatures of modern gas turbine engines exceed the maximum tolerable material temperatures by several hundreds of K. To ensure reliability of lifetime, complex cooling technology must be applied. Various cooling methods will be introduced in this lesson. Specific pros and cons will be identified and new concepts for further improvement of cooling will be discussed. Furthermore, the fundamentals of forced convection heat transfer and film cooling wil be imparted and a simplified design process of a cooled gas turbine components will be demonstrated. Finally, experimental and numerical methods for the characterization of heat transfer will be presented.

Course: Warehousing and distribution systems [2118097]

Coordinators: K. Furmans
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 19: Information Technology of Logistic Systems (p. 420)[SP_19_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

Learning Control / Examinations
oral / written (if necessary)

Conditions
none

Recommendations
logistics lecture

Learning Outcomes
Students are able to:

- Describe the areas of typical warehouse and distribution systems with the respective processes and can illustrate it with sketches,
- Use and choose strategies of warehouse and distribution systems according to requirements,
- Classify typical systsems using criteria discussed in the lecture, and
- Reson about the choice of appropriate technical solutions.

Content

- Introduction
- Yard management
- Receiving
- Storage and picking
- Workshop on cycle times
- Consoldiation and packing
- Shipping
- Added Value
- Overhead
- Case Study: DCRM
- Planning of warehouses
- Case study: Planning of warehouses
- Distribution networks
- Lean Warehousing

Media
presentations, black board

Literature
ARNOLD, Dieter, FURMANS, Kai (2005)
Materialfluss in Logistiksystemen, 5. Auflage, Berlin: Springer-Verlag
ARNOLD, Dieter (Hrsg.) et al. (2008)
Handbuch Logistik, 3. Auflage, Berlin: Springer-Verlag
BARTHOLDI III, John J., HACKMAN, Steven T. (2008)
Warehouse Science
GUDEHUS, Timm (2005)
Logistik, 3. Auflage, Berlin: Springer-Verlag
FRAZELLE, Edward (2002)
World-class warehousing and material handling, McGraw-Hill
MARTIN, Heinrich (1999)
Praxiswissen Materialflußplanung: Transport, Hanshaben, Lagern, Kommissionieren, Braunschweig, Wiesbaden: Vieweg
WISSER, Jens (2009)
Der Prozess Lagern und Kommissionieren im Rahmen des Distribution Center Reference Model (DCRM); Karlsruhe : Universitätsverlag
A comprehensive overview of scientific papers can be found at:
ROODBERGEN, Kees Jan (2007)
Warehouse Literature

Remarks
none

Course: Laser in automotive engineering [2182642]

Coordinators: J. Schneider
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
oral examination (ca. 30 min)

no tools or reference materials

Conditions
It is not possible, to combine this lecture with the lecture *Physical basics of laser technology* [2181612].

Recommendations
Basic knowledge of physics, chemistry and material science is assumed.

Learning Outcomes
The student

- can explain the principles of light generation, the conditions for light amplification as well as the basic structure and function of Nd:YAG-, CO_2- and high power diode-laser sources.
- can describe the most important methods of laser-based processing in automotive engineering and illustrate the influence of laser, material and process parameters
- can analyse manufacturing problems and is able to choose a suitable laser source and process parameters.
- can explain the requirements for safe handling of laser radiation and for the design of safe laser systems.

Content
Based on a short description of the physical basics of laser technology the lecture reviews the most important high power lasers and their various applications in automotive engineering. Furthermore the application of laser light in metrology and safety aspects will be addressed.

- physical basics of laser technology
- laser beam sources (Nd:YAG-, CO_2-, high power diode-laser)
- beam properties, guiding and shaping
- basics of materials processing with lasers
- laser applications in automotive engineering
- economical aspects
- savety aspects

Media
lecture notes via ILIAS

Literature
W. M. Steen: Laser Material Processing, 2010, Springer
W. T. Silfvast: Laser Fundamentals, 2008, Cambridge University Press

Remarks
It is allowed to select only one of the lectures “Laser in automotive engineering” (2182642) or “Physical basics of laser technology” (2181612) during the Bachelor and Master studies.

Course: Leadership and Management Development [2145184]

Coordinators: A. Ploch

Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach], SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The students are able to name, explain und discuss the main elements of leadership theories, methods and management development basics as well as the bordering topics of change management, intercultural competences, team work and corporate governance.

Content
Leadership theories
Management tools
Communication as management tool
Change management
Management development and MD-Programs
Assessment center and management audits
Team work, team development und team roles
Intercultural competences
Leadership and ethics, Corporate Governance
Executive Coaching
Lectures of industrial experts

Course: Laboratory Exercise in Energy Technology [2171487]

Coordinators: H. Bauer, U. Maas, H. Wirbser
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach]

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

Learning Control / Examinations
1 report, approx. 12 pages
Discussion of the documented results with the assistents

Duration: 30 minutes

no tools or reference materials may be used

Conditions
none

Recommendations
none

Learning Outcomes
Attending this course enables the students to:

- accomplish design related, experimental, numerical, analytical or theoretical tasks with a scientific background
- perform a correct evaluation of the obtained results
- adequately document and present their results in a scientific framework

Content
ITS topics
At ITS students will work on tasks, which will be defined each semester by the research asisstants, similar to topics of Bachelor- and Master-Theses. The following tasks are therefore just exemplary:

- concept for accurate repeated positioning of a camera of a robot arm
- Advanced image processing using Python
- Investigation of fuel atomization using novel mathemtical methods with MATLAB®
- Development of a post-processing routine for the determination of wetted surface area from SPH particle data
- Modelling and calculation of heat transfer and temperature profiles of test rig components applying Finite-Element-Methods
- Extension of a simulation modell to investigate spray evaporation using OpenFOAM®
- Control of the settings of an acoustic levitator using LabVIEW®

ITT topics
At the ITT students can choose between eight topics and elaborate them in groups of two.

1. Investigation of the operating behavior of a heat pump (cold steam machine) by determining the coefficient of performance (CoP) of the system as a function of the temperature level.
2. Implementing and testing of an experimental cooling tower: investigation of the mixing of cold and warm air.
3. Determination of the ignition delay of alternative fuel mixtures (bio-ethanol, methanol, diesel) with a rapid compression machine.

4. Development of alternative burner systems for cooking with alternative fuels (replacement of wood, kerosene, gases and coal).
5. Experimental investigation of burner systems to reduce pollutant emissions and increase efficiency.
6. Design of novel heat storage systems for residential heating systems / heat pumps.
7. Development of absorption refrigeration systems from the waste heat of passenger cars.
8. Influence of thermal disturbances on a laminar flow.

Remarks
The time to process the topic is 120 hours, corresponding to 4 ETCS Credits. The students have to process the topic successfully till the beginning of the following semester. Otherwise, the Laboratory Exercise is not passed and the student has to process another topic in the following semester. The processing time in the semester is flexible and shall be arranged between the supervisor and the student by mutual agreement.
The registration and the allocation of the topics takes place within the first two weeks of the lecture period on ILIAS: https://ilias.studium.kit.edu

Course: Learning Factory “Global Production“ [2149612]

Coordinators: G. Lanza
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
The assessment is carried out as exam with a written (§4(2), 1 SPO) and oral part (§4(2), 2 SPO) and an assessment of another kind (§4(2), 3 SPO).

Conditions
Successful completion of the following courses:

- Integrated Production Planning [2150660]
- Global Production and Logistics – Part 1: Global Production [2149610]
- Quality Management [2149667]

Recommendations
Participation in the following courses:

- Integrated Production Planning [2150660]
- Global Production and Logistics – Part 1: Global Production [2149610]
- Quality Management [2149667]

Learning Outcomes
Students are able to . . .

- evaluate and select alternative locations using appropriate methods.
- use methods and tools of lean management to plan and manage production systems that are suitable for the location.
- use the Six Sigma method and apply goal-oriented process management.
- select an appropriate level of automation of the production units based on quantitative variables.
- make use of well-established methods for the evaluation and selection of suppliers.
- apply methods for planning a global production network depending on company-specific circumstances to sketch a suitable network and classify and evaluating it according to specific criteria.
- apply the learned methods and approaches with regard to problem solving in a global production environment and able to reflect their effectiveness.

Content
The learning factory “Global Production“ serves as a modern teaching environment for the challenges of global production. To make this challenges come alive, students can run a production of electric motors under real production conditions.
The course is divided into e-learning units and presence dates. The e-learning units help to learn essential basics and to immerse themselves in specific topics (e.g. selection of location, supplier selection and planning of production networks). The focus of the presence appointments is the case-specific application of relevant methods for planning and control of production systems that are suitable for the location. In addition to traditional methods and tools to organize lean production systems (e.g. Kanban and JIT/ JIS, Line Balancing) the lecture in particular deals with site-specific quality assurance and scalable automation. Essential methods for quality assurance in complex production systems are taught and brought to practical experience by a Six Sigma project. In the area of

scalable automation, it is important to find solutions for the adaption of the level of automation of the production system to the local production conditions (e.g. automated workpiece transport, integration of lightweight robots for process linking) and to implement them physically. At the same time safety concepts should be developed and implemented as enablers for human-robot collaboration.
The course also includes an excursion to the production plant for the manufacturing of electric motors of an industrial partner.
Main focus of the lecture:

- site selection
- site-specific factory planning
- site-specific quality assurance
- scalable automation
- supplier selection
- network planning

Media
e-learning platform ilias, powerpoint, photo protocol. The media are provided through ilias (https://ilias.studium.kit.edu/)

Literature
Lecture notes of the courses:

- Integrated Production Planning [2150660]
- Global Production and Logistics – Part 1: Global Production [2149610]
- Quality Management [2149667]

Remarks
For organizational reasons the number of participants for the course is limited to 20. Hence a selection process will take place. Applications are made via the homepage of wbk.

Course: Logistics - organisation, design and control of logistic systems [2118078]

Coordinators: K. Furmans
Part of the modules: SP 19: Information Technology of Logistic Systems (p. 420)[SP_19_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	de

Learning Control / Examinations
oral / written (if necessary)

examination aids: none

Conditions
None.

Recommendations
None.

Learning Outcomes
Students are able to:

- Describe logistical tasks,
- Design logistical systems suitable to the respective task,
- Dimension stocastical stock models,
- Determine essential influencing parameters on the bullwhip effect and
- Use optimizing solution methods.

Content
multistage logistic process chains
transport chain in logistic networks
distribution processes
distribution centers
logistics of production systems
dependencies between production and road traffic
information flow
cooperative strategies (like kanban, just-in-time, supply chain management)

Media
presentations, black board

Literature
None.

Remarks
none

Course: Automotive Logistics [2118085]

Coordinators: K. Furmans
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

Learning Control / Examinations
oral / written (if necessary)

Conditions
None.

Recommendations
None.

Learning Outcomes
Students are able to:

- Describe essential logistic questions, in a complex production network. As an example the automobile industry is used.
- Choose and apply solution possibilities for logistic problems in this area.

Content

- Logistic questions within the automobile industry
- basic model of automobile production and distribution
- relation with the suppliers
- Disposition and physical execution
- Vehicle production in the interaction of shell, paint shop and assembly
- Sequence planning
- Assembly supply
- vehicle distribution and linkage with selling processes
- Physical execution, planning and control

Media
presentations, black board

Literature
None.

Remarks
none

Course: Airport logistics [2117056]

Coordinators: A. Richter
Part of the modules: SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach], SP 19: Information Technology of Logistic Systems (p. 420)[SP_19_mach]

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

Learning Control / Examinations
oral / written (if necessary)

Conditions
none

Recommendations
None.

Learning Outcomes
Students are able to:

- Describe material handling and informations technology activities on airports,
- Evaluate processes and systems on airports as the law stands, and
- Choose appropriate processes and material handling systems for airports.

Content
Introduction
airport installations
luggage transport
passenger transport
security on the airport
legal bases of the air traffic
freight on the airport

Media
presentations

Literature
„Gepäcklogistik auf Flughäfen“ àhttp://www.springer.com/de/book/9783642328527

Remarks
Limited number of participants: allocation of places in sequence of application (first come first served)
Application via “ILIAS” mandatory
personal presence during lectures mandatory

Course: Localization of Mobile Agents [24613]

Coordinators: U. Hanebeck
Part of the modules: SP 40: Robotics (p. 445)[SP_40_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach]

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

Learning Control / Examinations

Conditions

None.

Recommendations

Basic knowledge of probability theory and linear algebra will be beneficial.

Learning Outcomes

- The student understands the basics of the problem, solution methods, and the required mathematical background.
- Furthermore, the student has knowledge about the theoretical foundations, the distinction between the four basic localization methods, and their advantages and disadvantages. For this purpose, a variety of applications are considered.

Content

This module provides a systematic introduction into the topic of localization methods. In order to facilitate understanding, the module is divided into four main topics. Dead reckoning treats the instantaneous determination of a vehicle's position based on dynamic parameters like velocity or steering angle. Localization with the help of measurements of known landmarks is part of static localization. In addition to the closed-form solutions for particular measurements (distances and angles), the least squares method for fusion arbitrary measurements is also introduced. Dynamic localization treats the combination of dead reckoning and static localization. The central part of the lecture is the derivation of the Kalman filter, which has been successfully applied in several practical applications. Finally, simultaneous localization and mapping (SLAM) is introduced, which allows localization in case of (partly) unknown landmark positions.

Media

- Handwritten lecture notes will be made available electronically.
- Figures and application examples on slides.
- More information can be retrieved from the information brochure available on the ISAS website.

Literature

Elective literature:
Lecture notes

Course: Machine Vision [2137308]

Coordinators: C. Stiller, M. Lauer

Part of the modules: SP 18: Information Technology (p. 419)[SP_18_mach], SP 04: Automation Technology (p. 409)[SP_04_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach]

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

Learning Control / Examinations
written exam

Conditions
None.

Recommendations
Fundamental knowledge in measurement, system, and control theory is helpful, e.g. from the lecture “Measurement and Control Theory”.

Learning Outcomes
Machine vision (or computer vision) describes the computer supported solution of visual tasks similar to human vision. The technical domain of machine vision includes numerical research areas like optics, digital signal processing, 3d measurement technology, and pattern recognition. Application areas for machine vision techniques can be found in automation and control, robotics, and intelligent vehicles, among others.
The lecture introduces the basic machine learning techniques and algorithms and illustrates their use. The lecture is composed out of 3 hours/week lecture and 1 hour/week computer exercises. In the computer exercises methods introduced in the lecture will be implemented in MATLAB and tested experimentally.

Content
1. Overview of machine vision
2. Image formation and image preprocessing techniques
3. Edge detection
4. Line and curve fitting
5. Color representation
6. Image segmentation
7. Camera optics and camera calibration
8. Illumination
9. 3d reconstruction
10. Pattern recognition

Literature
The slides of the lecture will be provided as pdf files. Further references will be announced in the lecture.

Course: Magnet Technology of Fusion Reactors [2190496]

Coordinators: W. Fietz, K. Weiss
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach]

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

Learning Control / Examinations
Oral examination of about 30 minutes

Conditions
None.

Recommendations
Knowledge in energy technology, power plants, material testing is welcomed

Learning Outcomes
The students know:

- Basic knowledge of superconductivity, superconducting cables and magnet construction
- Generation of low temperature, cryostat construction
- Material properties at low temperatures
- Magnet design and magnet safety
- High-temperature superconductor use in power application and magnet construction

Content
The goal of the lecture is to impart the fundamentals of construction of superconducting magnets. Magnet technology is inherently of multidisciplinary character e.g. material properties at low temperature, high voltage and high current technique. The use of superconductors is mandatory to reach highest magnetic fields with comparable small losses. Examples of magnets from power application, basic research and fusion reactor construction are discussed.
Lecture Content:

- Introduction to plasma, fusion and electromagnets
- Introduction superconductivity - basics and materials
- Creation of low temperatures, cryo-technique
- Material properties at low temperature
- Magnet design and calculation
- Magnet stability, quench safety and high voltage protection
- Magnet examples
- High-temperature superconductors (HTS)
- HTS-application (cable, motor/generator, FCL, current leads, fusion reactors)

Course: Magnetohydrodynamics [2153429]

Coordinators: L. Bühler
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
oral
Duration: 30 minutes
No auxiliary means

Conditions
none

Learning Outcomes
The students can describe the fundamentals of magnetohydrodynamics. They are qualified to explain the interrelations of electro and fluid dynamics so as to analyze magnetohydrodynamic flows in engineering applications or for phenomena in geo and astrophysics.

Content

- Introduction
- Basics of electro and fluid dynamics
- Exact solutions, Hartmann flow, pump, generator, channel flows
- Inductionless approximation
- Developing flows, change of cross-section, variable magnetic fields
- Alfven waves
- Stability, transition to turbulence
- Liquid dynamos

Literature
U. Müller, L. Bühler,2001,Magnetofluiddynamics in Channels and Containers, ISBN 3-540-41253-0, Springer
R. Moreau, 1990, Magnetohydrodynamics, Kluwer Academic Publisher
P. A. Davidson, 2001, An Introduction to Magnetohydrodynamics, Cambridge University Press
J. A. Shercliff, 1965, A Textbook of Magnetohydrodynamics, Pergamon Press

Course: Leadership and Conflict Management (in German) [2110017]

Coordinators: H. Hatzl
Part of the modules: SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach], SP 10: Engineering Design (p. 412)[SP_10_mach]

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

Learning Control / Examinations
Elective Subject: oral exam (approx. 30 min)
Optional Subject: oral exam (approx. 30 min)
Optional Subject Economics/Law: oral exam (approx. 30 min)

Conditions

- Compact course
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required
- Compulsory attendance during the whole lecture

Recommendations

- Knowledge of Work Science and Economics is helpful

Learning Outcomes

- Knowledge of techniques for management and leadership
- Preparation for management and leadership tasks in the job

Content

1. Introduction to the course
2. Goal definition and goal achievement
3. Management techniques within planning
4. Communication and information
5. Decision-making
6. Leadership and co-operation
7. Self management
8. Conflict management
9. Case studies

Literature
Handout and literature are available on ILIAS for download.

Course: Machine Dynamics [2161224]

Coordinators: C. Proppe
Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], (p. 465)[SP_60_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], (p. 466)[SP_61_mach]

ECTS Credits	Hours per week	Term	Instruction language
5	3	Summer term	en

Learning Control / Examinations
Written examination

Conditions
none

Recommendations
none

Learning Outcomes
Students are able to apply engineering-oriented calculation methods in order to model and to understand dynamic effects in rotating machinery. This includes the investigation of runup, stationary operation of rigid rotors including balancing, transient and stationary behavior of flexible rotors, critical speeds, dynamics of slider-crank mechanisms, torsional oscillations.

Content
1. Introduction
2. Machine as mechatronic system
3. Rigid rotors: equations of motion, transient and stationary motion, balancing
4. Flexible rotors: Laval rotor (equations of motion, transient and stationary behavior, critical speed, secondary effects), refined models)
5. Slider-crank mechanisms: kinematics, equations of motion, mass and power balancing

Literature
Biezeno, Grammel: Technische Dynamik, 2. Edition, 1953

Holzweißig, Dresig: Lehrbuch der Maschinendynamik, 1979

Dresig, Vulfson: Dynamik der Mechanismen, 1989

Course: Machine Dynamics II [2162220]

Coordinators: C. Proppe

Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], (p. 465)[SP_60_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], (p. 466)[SP_61_mach]

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

Learning Control / Examinations
oral exam, no auxiliary means allowed

Conditions
none

Recommendations
Machine Dynamics

Learning Outcomes
Students are able to develop and analyze detailed models in machine dynamics that encompass continuum models, fluid structure interaction, and stability analyses.

Content
• hydrodynamic bearings
• rotating shafts in hydrodynamic bearings
• belt drives
• virbation of turbine blades

Literature
R. Gasch, R. Nordmann, H. Pfützner: Rotordynamik, Springer, 2006

Course: Material flow in logistic systems [2117051]

Coordinators: K. Furmans
Part of the modules: SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

Learning Control / Examinations
The assessment (Prüfungsleistung anderer Art) consists of the following assignments:

- 40% assessment of the final case study as individual performance,
- 60% semester evaluation which includes working on 5 case studies and defending those (For both assessment types, the best 4 of 5 tries count for the final grade.):
  - 40% assessment of the result of the case studies as group work,
  - 20% assessment of the oral examination during the case study colloquiums as individual performance.

A detailed description of the learning control can be found under Annotations.

Conditions
None.

Recommendations
Recommended elective subject: Probability Theory and Statistics [0186000]

Learning Outcomes
After successful completion of the course, you are able (alone and in a team) to:

- Accurately describe a material handling system in a conversation with an expert.
- Model and parameterize the system load and the typical design elements of a material handling system.
- Design a material handling system for a task.
- Assess the performance of a material handling system in terms of the requirements.
- Change the main lever for inuencing the performance.
- Expand the boundaries of today's methods and system components conceptually if necessary.

Content

- Elements of material ow systems (conveyor elements, fork, join elements)
- Models of material ow networks using graph theory and matrices
- Queueing theory, calculation of waiting time, utilization
- Warehouseing and order-picking
- Shuttle systems
- Sorting systems
- Simulation
- Calculation of availability and reliability
- Value stream analysis

Media
Presentations, black board, book, video recordings

Literature
Arnold, Dieter; Furmans, Kai : Materialfluss in Logistiksystemen; Springer-Verlag Berlin Heidelberg, 2009

Remarks
Students are divided into groups for this course. Five case studies are carried out in these groups. The results of the group work during the lecture period are presented and evaluated in writing. In the oral examination during the case study colloquiums, the understanding of the result of the group work and the models dealt with in the course is tested. The participation in the oral defenses is compulsory and will be controlled. For the written submission the group receives a common grade, in the oral defense each group member is evaluated individually.
After the lecture period, there is the final case study. This case study contains the curriculum of the whole semester. The students work individually on this case study which takes place at a predefined place and time (duration: 4h).

Course: Materials and Processes for Body Lightweight Construction in the Automotive Industry [2149669]

Coordinators: D. Steegmüller, S. Kienzle
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students ...

- are able to name the various lightweight approaches and identify possible areas of application.
- are able to identify the different production processes for manufacturing lightweight structures and explain their functions.
- are able to perform a process selection based on the methods and their characteristics.
- are able to evaluate the different methods against lightweight applications on the basis of technical and economic aspects.

Content
The objective of the lecture is to build up an overview of the relevant materials and processes for the production of a lightweight body. This includes both the actual production and the joining for the body. The lecture covers the different lightweight approaches and possible fields of application in the automotive industry. The methods are discussed with practical examples from the automotive industry.
The following topics will be covered:

- lightweight designs
- aluminum and steel for lightweight construction
- fibre-reinforced plastics by the RTM and SMC process
- joining of steel and aluminum (clinching, riveting, welding)
- bonding
- coating
- finishing
- quality assurance
- virtual factory

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Mathematical Foundation for Computational Mechanics [2162240]

Coordinators: E. Schnack
Part of the modules: SP 31: Mechatronics (p. 435)[SP_31_mach]

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

Learning Control / Examinations
Oral examination. Duration: 20 minutes.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can specifically and efficiently apply the mathematical methods for modern numerics in mechanical engineering. They know and are able to describe the fundamentals of mathematical methods for elastic, dynamic, and multi-field continuum variation calculations. The students can name fundamental aspects of functional analysis and apply them to examples in order to describe and analyze error estimations in the finite element method (FEM) and the boundary element method (BEM). Based on these fundamental concepts, future challenges in mechanical engineering simulations are discussed.
The lecture notes are made available via ILIAS.

Content
Variational formulations. Functional analysis. Lagrange d process.Various function space definitions relating to the elasticity and dynamics of the mechanics. Measurements which enable the field calculation to be defined in applications.

Course: Mathematical Methods in Dynamics [2161206]

Coordinators: C. Proppe
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], (p. 466)[SP_61_mach]

ECTS Credits	Hours per week	Term	Instruction language
5	2	Winter term	de

Learning Control / Examinations
written examination

Conditions
none

Recommendations
none

Learning Outcomes
The students know the mathematical methods of dynamics precisely. They are able to use the basic mathematical methods for modelling the dynamical behaviour of elastic and rigid bodies.
The students have a basic understanding of the description of kinematics and kinetics of bodies. They also master the alternative formulations based on weak formulations and variational methods and the approximate solution methods for numerical calculations of the moving behaviour of elastic bodies.

Content
Dynamics of continua:
Concept of continuum, geometry of continua, kinematics and kinetics of continua

Dynamics of rigid bodies:
Kinematics and kinetics of rigid bodies

Variational principles:
Priniciple of virtual work, variational calculations, Principle of Hamilto

Approximate solution methods:
Methods of weighted residuals, method of Ritz

Applications

Literature
Lecture notes (available online)

J.E. Marsden, T.J.R. Hughes: Mathematical foundations of elasticity, New York, Dover, 1994

P. Haupt: Continuum mechanics and theory of materials, Berlin, Heidelberg, 2000

M. Riemer: Technische Kontinuumsmechanik, Mannheim, 1993

K. Willner: Kontinuums- und Kontaktmechanik : synthetische und analytische Darstellung, Berlin, Heidelberg, 2003

J.N. Reddy: Energy Principles and Variational Methods in applied mechanics, New York, 2002

A. Boresi, K.P. Chong, S. Saigal: Approximate solution methods in engineering mechanics, New York, 2003

Course: Mathematical Methods in Strength of Materials [2161254]

Coordinators: T. Böhlke
Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach]

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

Learning Control / Examinations
depending on choice according to acutal version of study regulations
Additives as announced.

Conditions
Prerequisites are met by solution of homework problems.

Recommendations
None.

Learning Outcomes
The students can

- perform the most important tensor operatons in example problems
- classify tensors of second order according to their properties
- apply elements of tensoranalysis
- describe the kinematics of infinitesimal and finite deformations in tensorial notation
- derive balance laws of mechanics
- solve problems of elasticity and thermoelasticity using tensor notation
- apply the theoretical concepts of the lecture to special problems

Content
Tensor algebra

- vectors; basis transformation; dyadic product; tensors of 2nd order
- properties of 2nd order tensors: symmetry, anti-symmetry, orthogonality etc.
- eigenvalue problem, theorem of Cayley-Hamilton, invariants; tensors of higher order
- tensor algebra in curvilinear coordinate systems
- tensor analysis in curvilinear coordinate systems
- Differentiation of tensor functions

Application of tensor calculus in strength of materials

- kinematics of infinitesimal and finite deformations
- transport theorem, balance equations, stress tensor
- theory of elasticity
- thermo-elasticity

Literature
lecture notes
Bertram, A.: Elasticity and Plasticity of Large Deformations - an Introduction. Springer 2005.
Liu, I-S.: Continuum Mechanics. Springer, 2002.
Schade, H.: Tensoranalysis.Walter de Gruyter, New York, 1997.
Wriggers, P.: Nichtlineare Finite-Element-Methoden. Springer, 2001.

Course: Mathematical methods of vibration theory [2162241]

Coordinators: W. Seemann
Part of the modules: (p. 465)[SP_60_mach], (p. 466)[SP_61_mach]

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

Learning Control / Examinations
written or oral exam
Announcement 6 weeks prior to examination date.

Conditions
None.

Recommendations
Engineering Mechanics III, IV

Learning Outcomes
The students know to solve single differential equations with constant coefficients by various methods. For inhomogenious differential equations the inhomogenity may be arbitrary. They realize the relations between the different methods. For matrix-differential equations the students may derive the eigenvalue problem for free vibration and may obtain solutions for eigenvalues and eigenvectors. They know the modal transformation which is helpful to solve forced vibration. They may decide about stability of time-independent steady state solutions of nonlinear systems. They can derive boundary value problems by variational methods and know in principle how to solve them. For simple one-dimensional continua they may get analytical solutions. They can apply perturbation methods to derive analytical solutions for problems with small parameters.

Content
Linear, time-invariant, ordinary single differential equations: homogeneous solution; harmonic, periodic and non-periodic excitations; Duhamel's integral; Fourier and Laplace transform; introduction into the theory of distributions; Systems of ordinary differential equations: matrix notation, eigenvalue theory, fundamental matrix, forced vibrations via modal expansion and transition matrix; Introduction into the dynamic stability theory; Partial differential equations: solution in product form, eigenvalue theory, modal expansion using Ritz series; Variational methods, Hamilton's principle, boundary value problems representing vibrating continua; Perturbation methods

Literature
Riemer, Wedig, Wauer: Mathematische Methoden der Technischen Mechanik

Course: Mathematical Methods in Fluid Mechanics [2154432]

Coordinators: B. Frohnapfel, D. Gatti
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	de

Learning Control / Examinations
written

duration: 3 hours

Aux. means: formula sheet, pocket calculator

Conditions
None.

Recommendations
Basic Knowledge about Fluid Mechanics

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

Content
The lecture will cover a selection of the following topics:

- Potential flow theory
- Creeping flows
- Lubrication theory
- Boundary-layer theory
- Laminar-turbulent transition (linear stability theory)
- Turbulent flows
- Numerical solution of the governing equation (finite difference methods)

Media
chalk board, Power Point

Literature
Kundu, P.K., Cohen, K.M.: Fluid Mechanics, Elsevier, 4th Edition, 2008
Batchelor, G.K.: An Introduction to Fluid Dynamics, Cambridge Mathematical Library, 2000
Pope, S. B.: Turbulent Flows, Cambridge University Press, 2000
Ferziger, H., Peric, M.: Computational Methods for Fluid Dynamics, Springer, 2008

Course: Mathematical Methods in Structural Mechanics [2162280]

Coordinators: T. Böhlke
Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 30: Applied Mechanics (p. 434)[SP_30_mach]

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

Learning Control / Examinations
depending on choice according to acutal version of study regulations
Additives as announced.

Conditions
Prerequisites are met by solving exercises.

Recommendations
This course is geared to MSc students. The contents of the lecture "Mathematical methods in Strength of Materials" are a prerequisite.

Learning Outcomes
The students can

- apply methods of variational calculus for solving problems of linear elasticity
- assess mesoscopic and macroscopic können mesoskopische und makroskopische Spannungs- und Dehnungsmaße beurteilen
- apply and evaluate the methods of homogenization of elastic and thermo-elastic properties
- list methods of homogenization of elastic-plastic properties
- solve worksheet problems to topics of the lecture using technical-mathematical software

Content
Basics of variational calculus

- functionals; Frechet-differential; Gateaux-differential; maximum or minimum problems
- lemma of variational calculus and Lagrange delta-process; Euler-Lagrange-equations

Applications: Principals of continuums mechanics

- variational principals in mechanics; variational formulierung of boundary value problem of elastostatic

Applications: Homogenization methods for materials with microstructure

- mesoscopic and macroskopic stress and strain measures
- Mean values of ensembles, ergodicity
- effective elastic properties
- Homogenization of thermo-elastic properties
- Homogenization of plastic and visco-plastic properties
- Fe-based homogenization

Literature
Vorlesungsskript
Gummert, P.; Reckling, K.-A.: Mechanik. Vieweg 1994.
Gross, D., Seelig, T.: Bruchmechanik – Mit einer Einführung in die Mikromechanik.
Springer 2002.
Klingbeil, E.: Variationsrechnung, BI Wissenschaftsverlag, 1977
Torquato, S.: Random Heterogeneous Materials. Springer, 2002.

Course: Mathematical models and methods in combustion theory [2165525]

Coordinators: V. Bykov, U. Maas
Part of the modules: SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

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

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
None

Learning Outcomes
The attendance of this course enables students to:

- study, understand and apply the fundamental concepts of combustion modelling,
- develop ideal models for the description of auto-ignition, explosions, flame quenching and detonations,
- understand the basic mathematical (asymptotic) methods applied in the analysis of these models,
- perform a mathematical analysis of the models,
- determine the mathematical properties of the solutions obtained from the models.

Content
The lecture shall introduce the basics of the mathematical modeling and the analysis of reacting flow systems. The fundamental models of combustion processes are outlined together with asymptotical methods, which deliver reasonable approximate solutions for numerous combustion processes. Many examples of simplified models for the description of auto-ignition, explosions, flame quenching and detonations will be presented and discussed. The main analytical methods will be illustrated using these simple examples.

Literature
Combustion Theory, F A Williams, (2nd Edition), 1985, Benjamin Cummins.
Combustion - Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation, J. Warnatz, U. Mass and R. W. Dibble, (3nd Edition), Springer-Verlag, Heidelberg, 2003.
The Mathematical Theory of Combustion and Explosions, Ya.B. Zeldovich, G.I. Barenblatt, V.B. Librovich, G.M. Makhviladze, Springer, New York and London, 1985.

Course: Mathematical models and methods for Production Systems [2117059]

Coordinators: K. Furmans, M. Rimmele
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 28: Lifecycle Engineering (p. 432)[SP_28_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach], SP 40: Robotics (p. 445)[SP_40_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Winter term	en

Learning Control / Examinations
oral

examination aids: none

Conditions
none

Recommendations
Basic knowledge of statistic
recommended compusory optional subject:

- Stochastics in Mecanical Engineering

recommended lecture:

- Material flow in logistic systems (also parallel)

Learning Outcomes
Students are able to:

- Describe material flow systems with analytical solvable stochastic models,
- Derive Approches for control systems (KANBAN) based on easy models of queueing theory,
- Execute practical exercised on workstations and
- Use simulation and exakt methods.

Content

- single server systems: M/M/1, M/G/1: priority rules, model of failures
- networks: open and closed approximations, exact solutions and approximations
- application to flexible manufacturing systems, AGV (automated guided vehicles) - systems
- modeling of control approaches like constant work in process (ConWIP) or kanban
- discrete-time modeling of queuing systems

Media
black board, lecture notes, presentations

Literature
Wolff: Stochastic Modeling and the Theory of Queues, Prentice Hall, 1989

Shanthikumar, Buzacott: Stochastic Models of Manufacturing Systems

Course: Mechanics of laminated composites [2161983]

Coordinators: E. Schnack
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
Oral examination. Duration: 20 minutes.

Conditions
none

Recommendations
none

Learning Outcomes
After having attended the course, students can name the types and properties, applications as well as drawbacks and advantages of composite materials and describe them in comparison to conventional materials. Moreover, they can explain the terms “lamina,” “laminae,” and “laminate” in detail and with reference to examples. Based on this introduction, students are able to classify modern composites, particularly when they use these materials to design machine structures.
Based on the courses of technical mechanics, the students then derive the basic equations for composites. The students summarize the behavior of the components of the equations in adequate formulas and develop strategies to synthesize from individual formulas a describing formula for the formation of a material composite. Doing this, the students take into account special properties of composites (dependence on direction, temperature, air humidity) and can describe and analyze them by way of example.
Using a concrete practical example, the students independently derive adequate formulas and can describe transformation processes required for other applications. In addition, they can describe and analyze the corresponding structural behavior and, hence, develop/design materials in a goal-oriented way.
The lecture notes are made available via ILIAS.

Content
Definition of composites, definition of static and kinematic groups. Definition of material laws. Transformation of the state values of composites and transformation of the material properties for the coordinate systems in the design of machine structures.

Course: Mechanics and Strength of Polymers [2173580]

Coordinators: B. Graf von Bernstorff
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 36: Polymer Engineering (p. 442)[SP_36_mach]

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

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
None.

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

Learning Outcomes
The students are prepared to

- repeat the calculus on strength and design of engineering parts exposed to complex loadings,
- estimate the influence of time and temperature on the strength of polymeric materials,
- relate the strength of materials to their molecular structure, morphology and processing parameters and
- derive failure mechanisms for homogenuous polymers and composite materials therefrom.

Content
Molecular structure and morphology of polymers, temperature- and time dependency of mechanical behavior, viscoelasticity, time/temperature- superposition principle, yielding, crazing and fracture of polymers, failure criterions, impact and dynamic loading, corresponding principle, tough/brittle-transition, introduction to the principles of fiber reinforcement and multiple cracking in composites

Literature
A literature list, specific documents and partial lecture notes shall be handed out during the lecture.

Course: Mechanics in Microtechnology [2181710]

Coordinators: P. Gruber, C. Greiner
Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
oral exam ca. 30 minutes

Conditions
none

Learning Outcomes
The students know and understand size and scaling effects in micro- and nanosystems. They understand the impact of mechanical phenomena in small dimensions. Based on this they can judge how they determine material processing as well as working principles and design of microsensors and microactuators.

Content
1. Introduction: Application and Processing of Microsystems
2. Scaling Effects
3. Fundamentals: Stress and Strain, (anisotropic) Hooke's Law
4. Fundamentals: Mechanics of Beams and Membranes
5. Thin Film Mechanics: Origin and Role of Mechanical Stresses
6. Characterization of Mechanical Properties of Thin Films and Small Structures: Measurement of Stresses and Mechnical Parameters such as Young'sModulus and YieldDtrength; Thin Film Adhesion and Stiction
7. Transduction: Piezo-resistivity, Piezo-electric Effect, Elektrostatics,...
8. Aktuation: Inverse Piezo-electric Effect, Shape Memory, Elektromagnetic Actuation,. . .

Literature
Folien,
1. M. Ohring: „The Materials Science of Thin Films“, Academic Press, 1992
2. L.B. Freund and S. Suresh: „Thin Film Materials“
3. M. Madou: Fundamentals of Microfabrication“, CRC Press 1997
4. M. Elwenspoek and R. Wiegerink: „Mechanical Microsensors“ Springer Verlag 2000
5. Chang Liu: Foundations of MEMS, Illinois ECE Series, 2006

Course: Laboratory mechatronics [2105014]

Coordinators: C. Stiller, M. Lorch, W. Seemann

Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 10: Engineering Design (p. 412)[SP_10_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach]

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

Learning Control / Examinations
certificate of successful attendance

Conditions
none

Learning Outcomes
The student is able to ...

- use his knowledge about mechatronics and microsystems technology to solve a practical problem. The laboratory course comprises simulation, bus communication, measurement instrumentation, control engineering and programming.
- integrate the different subsystems from a manipulator to a working compound system in teamwork.

Content
Part I
Control, programming and simulation of robots
CAN-Bus communication
Image processing / machine vision
Dynamic simulation of robots in ADAMS

Part II
Solution of a complex problem in team work

Literature
Manuals for the laboratory course on Mechatronics

Course: Human-Machine-Interaction [24659]

Coordinators: M. Beigl
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 31: Mechatronics (p. 435)[SP_31_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	de

Learning Control / Examinations
The assessment is explained in the module description.

Conditions
None.

Learning Outcomes
-

Content

Literature
David Benyon: Designing Interactive Systems: A Comprehensive Guide to HCI and Interaction Design. Addison-Wesley Educational Publishers Inc; 2nd Revised edition edition; ISBN-13: 978-0321435330
Steven Heim: The Resonant Interface: HCI Foundations for Interaction Design. Addison Wesley; 1 edition (March 15, 2007) ISBN-13: 978-0321375964

Course: Measurement Technology [23105]

Coordinators: F. Puente
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach]

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

Learning Control / Examinations
Written Exam

Conditions
None.

Recommendations
Wahrscheinlichkeitstheorie, Komplexe Analysis und Integraltransformationen, Signale und Systeme

Learning Outcomes
The goal is to relay theoretical fundamentals.

Content
This lecture addresses bachelor students in the fifth semester of Electrical Engineering.
Firstly the terms measurement and characteristic measurement curve are introduced. Possible sources of measurement errors are presented and these errors are classified as either systematic or stochastic. In the course of the lecture, means to reduce both classes of errors are illustrated.
Since the characteristic curve of real world measurement systems is in general not given analytically, it must be derived from a set of given measurements. Therefore basic curve fitting schemes are discussed, including approximation (least squares) and interpolation (Lagrange and Newton polynomial interpolation, spline interpolation) methods.
Another part of the lecture covers the steady-state behaviour of measurement systems. Therefore the ideal characteristic curve, which is assumed for most measurement systems, is introduced and errors that arise hereby are evaluated. Afterwards, concepts to reduce these errors are presented for working both under specified normal conditions and with aberrations thereof.
In order to cope with stochastic measurement errors the basics of probabilistic theory are reviewed in short. As a new instrument to gain information about the unknown probability densities of the observed quantities, samples are introduced. Furthermore, parameter tests and goodness-of-fit tests as statistical hypothesis tests to prove/refute statements about these densities are presented.
As another powerful measurement tool, correlational measurement is subject matter of another part of the lecture and stochastic processes as necessary basics to this are went over in short. Based on it applications for transit time measurement and Doppler measurement are presented. The power-density spectrum is defined as the fourier transform of the correlation function and provides means for system identification. Also the Wiener filter as an optimal filter for signal reconstruction is covered.
Given that processing of real world measurements takes place mostly on digital computers, errors introduced by analogue/digital conversion are discussed for both the time- and amplitude-domain. Therefore the sampling- and quantization-theorem and means to fulfill both of them (anti-aliasing filter, dither) are presented as well as common ADC and DAC converter principles.

Literature
Literature: F. Puente León, U. Kiencke, R. Eger; Messtechnik; 8. überarbeitete Auflage 2011. G. Lebelt und F. Puente; Übungsaufgaben zur Messtechnik und Sensorik

Remarks
The course comprises of the interleaved lecture blocks and exercises. Current information can be found on the IIIT (www.iiit.kit.edu) webpage.

Course: Measurement II [2138326]

Coordinators: C. Stiller
Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach]

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

Learning Control / Examinations
written examination

Conditions
None.

Recommendations
Fundamentals in measurement, system and control theory, e.g. from the lecture “Measurement and Control Systems”

Learning Outcomes
The capabilities of modern sensor technology pave the way for novel applications in engineering. Especially digital measurement techniques may be used even in very complex environments and thus have strong impact on technological progress. Stochastic models of measurement processes form the basis for meaningful information processing and provide a valuable tool for engineering. This interdisciplinary lecture addresses students in mechanical engineering and related subjects. The lecture gives an overview of digital technology and stochastics. These areas form the basics of estimation methods that can be embedded elegantly in the theory of state observers. Applications in signal processing for modern environmental perception (video, Lidar, Radar) illustrate the discussed subjects.

Content
1. Digital technology
2. Stochastic modeling for measurement applications
3. Estimation
4. Bayes & Kalman Filter
5. Environmental perception

Literature
Script in German

Course: Analysis tools for combustion diagnostics [2134134]

Coordinators: J. Pfeil
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

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

Learning Control / Examinations
oral examination, Duration: 25 min., no auxiliary means

Conditions
none

Recommendations
Fundamentals of Combustion Engines helpful

Learning Outcomes
The students can name and explain state-of-the-art methods to analyse the process in combustion as well as special measuring techniques such as optical and laser analysis. They are able to thermodynamically model, analyse and evaluate the engine process.

Content
energy balance at the engine
energy conversion in the combustion chamber
thermodynamics of the combustion process

flow velocities

flame propagation

special measurement techniques

Literature
Lecture notes available in the lectures

Course: Microenergy Technologies [2142897]

Coordinators: M. Kohl
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

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

Learning Control / Examinations
as elective subject in major field or as optional subject, oral exam, 30 minutes

Conditions
None.

Recommendations
The lecture addresses students in the fields of mechanical engineering, energy technologies, mechatronics and information technology. A comprehensive introduction is given in the basics and current developments in this new and very dynamically evolving field.
The lecture is (supplementary/compulsory) in the master course of „Micro Energy Technologies“ and supplementary in the major of „Mechatronics and Microsystems Technology“ in Mechanical Engineering.
Mechanical Engineering: Major M&M
Energy Technologies: NN
Energietechnik: NN

Learning Outcomes
- Knowledge of the principles of energy conversion
- Knowledge of the underlying concepts of thermodynamics and materials science
- Explanation of layout, fabrication and function of the treated devices
- Calculation of important properties (time constants, forces, displacements, power, degree of efficiency, etc.)
- Development of a layout based on specifications

Content
- Basic physical principles of energy conversion
- Layout and design optimization
- Technologies
- Selected devices
- Applications

The lecture includes amongst others the following topics:
Micro energy harvesting of vibrations
Thermal micro energy harvesting
Microtechnical applications of energy harvesting
Heat pumps in micro technology
Micro cooling

Literature
- Lecture notes (overhead transparencies) „Micro Energy Technologies“
- Stephen Beeby, Neil White, Energy Harvesting for Autonomous Systems, Artech House, 2010
- Shashank Priya, Daniel J. Inman, Energy Harvesting Technologies, Springer, 2009

Course: Micro Magnetic Resonannce [2141501]

Coordinators: J. Korvink, N. MacKinnon
Part of the modules: SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
Own Presentation, participation at the course discussions, result is passed or failed.

Conditions
None.

Recommendations
See literature list.

Learning Outcomes
Attendees aquire fundamental insights into microsystem concepts for **nuclear magnetic resonance and imaging (NMR and MRI)**.

Content
Nuclear magnetic resonance (**NMR**), or magnetic resonance in general (**MR**) is a powerful, **non-invasive technique** useful for gaining atomic level structural details on samples ranging from soluble small molecules to large membrane bound proteins. As an imaging technology, it can provide information on morphology, composition, as well as transport phenomena. For example, it is possible to visualise fluid dynamics such as the course of blood in the body or in a microfluidic system, or the anisotropic diffusion in the brain or a porous medium. Also in the development of batteries, and in chemical engineering procedures, NMR provides quantitative and qualitative information.
Traditional NMR hardware used for exciting the sample and detecting the signal is traditionally on the macroscale in terms of physical dimensions. Recently, miniaturization of NMR systems has developed into an active research area driven primarily by the enhanced mass sensitivity and the ability for system integration with smaller NMR detectors.
In this seminar course, we will explore some of the **state-of-the-art applications** of **micro-NMR** and **nano-NMR**. A selection of representative research papers will be provided, from which each student will select one paper to learn in depth and finally present in a style as if they performed the research themselves. The course will first offer a **series of introductory lectures**, followed by a **series of tutorial sessions** in which each student may discuss with experts. Finally, individual **student presentations** with discussion will be held.
Topics to be offered:

- Novel micro-NMR detectors (solenoid, strip line, microslot, CMOS, printed, etc.)
- Novel nano-MR detectors (MRFM, NV centers, etc.)
- Computation (design optimization, MOR, MRI image processing, NMR spectral prediction, etc.)
- Signal enhancement strategies (hyperpolarization DNP, PHiP, Xe, refrigeration)
- System hyphenation (chromatography, flow cells, LoC, orthogonal analysis, etc.)
- Complex mixtures (metabolomics, in vivo applications on small organisms)
- Biomedical MR sensors (catheters, implantable, etc.)

Literature
The Links to literature journal articles will be provided to the students. Example research journal sources will include Nature, Nature Communications, Science, PNAS, JMR, etc. For general reading, some recommended sources are:

- Principles of Nuclear Magnetic Resonance Microscopy, Callaghan, P (1994), Oxford University Press.
- Spin Dynamics: Basics of Nuclear Magnetic Resonance 2nd Ed., Levitt, M (2013), John Wiley & Sons.
- NMR Probeheads for Biophysical and Biomedical Experiments – Theoretical Principles, Mispelter, J; Lupu, M; Briguet, A (2006) Imperial College Press.

Course: Micro- and nanosystem integration for medical, fluidic and optical applications [2105032]

Coordinators: L. Koker, U. Gengenbach, I. Sieber
Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach]

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

Learning Control / Examinations
Oral
Duration: 30 min

Conditions
none

Learning Outcomes
The students . . . :

- have a fundamental understanding of modeling using analogies
- know the basics of modeling and simulation in design of mechanical, optical, and fluidic subsystems
- can assess the need for inter-domain simulations
- understand the challenges in the design of active implants
- have an overview of different active implants and their applications
- know approaches to system integration and packaging of active implants
- are familiar with different methods of testing with the focus on hermeticity
- have an overview of processes for the integration of micro-optical and micro-fluidic subsystems
- gain insight into technical applications of self-assembly processes

Content

- Introduction to the role of system integration in the product development process
- Simplistic modeling and use of analogies in system design
- Introduction to modeling and simulation in system design
- Mechanics simulation
- Optics simulation
- Fluidics simulation
- Coupling of simulation tools
- Requirements for system integration of active implants
- Design of active implants
- Approaches to system integration of active implants
- Test methods (hermeticity, accelerated aging etc.)
- Micro-optical subsystems
- Micro-fluidic subsystems
- Self-assembly as integration process at micro and nano scale

Course: Microactuators [2142881]

Coordinators: M. Kohl
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach]

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

Learning Control / Examinations
(1) as core subject in the major “Micoactuators and Microsensors” combined with the core subject “New Actuators and Sensors”, oral, 60 minutes
or
(2) as elective subject in the other major fields
or
(3) as optional subject, oral exam, 30 minutes

Conditions
None.

Recommendations
The lecture addresses students in the fields of mechanical engineering, mechatronics and information technology, materials science and engineering, electrical engineering and economic sciences. A comprehensive introduction is given in the basics and current developments on the microscopic length scale.
The lecture is core subject of the major course “Microactuators and Microsensors” of the specialization “Mechatronics and Microsystems Technology” in Mechanical Engineering.
Mechanical Engineering: Specialization M&M / Major 54

Learning Outcomes
- Knowledge of the actuation principles including pros and cons
- Knowledge of important fabrication technologies
- Explanation of layout and function of the microactuators
- Calculation of important properties (time constants, forces, displacements, etc.)
- Development of a layout based on specifications

Content
- Basic knowledge in the material science of the actuation principles
- Layout and design optimization
- Fabrication technologies
- Selected developments
- Applications

The lecture includes amongst others the following topics:

- Microelectromechnical systems: linear actuators, microrelais, micromotors
- Medical technology and life sciences: Microvalves, micropumps, microfluidic systems
- Microrobotics: Microgrippers, polymer actuators (smart muscle)
- Information technology: Optical switches, mirror systems, read/write heads

Literature
- Lecture notes
- D. Jendritza, Technischer Einsatz Neuer Aktoren: Grundlagen, Werkstoffe, Designregeln und Anwendungsbeispiele, Expert-Verlag, 3. Auflage, 2008
- M. Kohl, Shape Memory Microactuators, M. Kohl, Springer-Verlag Berlin, 2004
- N.TR. Nguyen, S.T. Wereley, Fundamentals and applications of Microfluidics, Artech House, Inc. 2002
- H. Zappe, Fundamentals of Micro-Optics, Cambride University Press 2010

Course: Modelling of Microstructures [2183702]

Coordinators: A. August, B. Nestler, D. Weygand
Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 30: Applied Mechanics (p. 434)[SP_30_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach]

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

Learning Control / Examinations
We regularly hand out exercise sheets. The individual solutions will be corrected.
oral exam ca. 30 min

Conditions
none

Recommendations
materials science
fundamental mathematics

Learning Outcomes
The student can

- explain the thermodynamic and statistical foundations for liquid-solid and solid-solid phase transition processes and apply them to construct phase diagrams.
- explain the mechanisms of grain and phase boundary motion induced by external fields
- use the phase-field method for simulation of microstructure formation processes using modeling approaches and challenges of current research
- has experiences in computing and conduction simulations of microstructure formation from an integrated computer lab.

Content
• Brief Introduction in thermodynamics
• Statistical interpretation of entropy
• Gibbs free energy and phase diagrams
• Auxiliarythermodynamic functions
• Phase diagrams
• Phase transformations and driving forces
• The Energy functional and the surface tension
• The phase field equation
• Conservation equations
• A multicomponent multiphase field model
• Onsager reciprocal relations

Media
Black board and slides, laptops for computer lab, exercise sheets

Literature

1. Gottstein, G. (2007) Physikalische Grundlagen der Materialkunde. Springer Verlag Berlin Heidelberg
2. Kurz, W. and Fischer, D. (1998) Fundamentals of Solidification. Trans Tech Publications ltd, Switzerland Germany UK USA
3. Porter, D.A. Eastering, K.E. and Sherif, M.Y. (2009) Phase transformation in metals and alloys (third edition). CRC Press, Taylor & Francis Group, Boca Raton, London, New York
4. Gaskell, D.R., Introduction to the thermodynamics of materials

Course: Microsystem Simulation [2142875]

Coordinators: J. Korvink
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	en

Learning Control / Examinations
written exam

Conditions
None.

Learning Outcomes

Content

Course: Microsystem product design for young entrepreneurs [2141503]

Coordinators: J. Korvink, D. Mager
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
The class is a laboratory course that is taken in groups, hence the active and productive participation in the team effort is evaluated. To check the individual performance, there will be weekly discussions about the project. To evaluate each group's progress, there will be 2 presentation during the duration of the course. The final mark is determined from the marks obtained in the presentation and an oral group examination of 1 hour.

Conditions
none.

Recommendations
Interest to work in a (multidisciplinary) team and jointly build a product.

Learning Outcomes
The participants should learn to apply their **theoretical knowledge** to a real world scenario. Therefore, they need to understand their **own skills** and defend them within the group. Besides the joy of working on a fascinating project, the students will also gain confidence in their own skills, as well as gaining the insight that the route from an idea to a product is tough and needs to be organised.

Content
The goal of the laboratory course is to elaborate the group's expertise, and based on that unique combination, to derive a product that fits. A prototype of the idea shall be built and a marketing concept will be developed. At the end of the course, a status should be reached that allows (if wanted) to submit an entry the **MEMS competion COSIMA**, or even to run for a **Kickstarter Campaign**.

Media
http://Kickstarter.com
http://Indigogo.com
http://partner.vde.com/cosima-mems/Pages/Homepage.aspx

Remarks
The lab course is for attendees who want to try out their learned skills and/or realise an idea of their own.

Course: Miniaturized Heat Exchangers [2142880]

Coordinators: J. Brandner
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
oral exam, 30 minutes

Conditions
None.

Learning Outcomes

Content

Course: Mobile Machines [2114073]

Coordinators: M. Geimer
Part of the modules: SP 34: Mobile Machines (p. 441)[SP_34_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	4	Summer term	de

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

Conditions
None.

Recommendations
Knowledge in Fluid Power Systems is required. It is recommended to attend the course *Fluid Power Systems* [2114093] beforehand.

Learning Outcomes
After completion of the course the students have knowledge of:

- a wide range of mobile machines
- operation modes and working cycles of important mobile machines
- selected subsystems and components

Content

- Introduction of the required components and machines
- Basics and structure of mobile machines
- Practical insight in the development techniques

Media
Download of lecture slides via ILIAS.

Remarks
The course will be replenished by interesting lectures of professionals from leading hydraulic companies.

Course: Model based Application Methods [2134139]

Coordinators: F. Kirschbaum
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

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

Learning Control / Examinations
take-home exam, short presentation with oral examination

Conditions
none

Recommendations
knowledge in Basics of combustion engines, vehicular systems, control theorie and statistics.

Learning Outcomes
The student can name the most important methods for model-based calibration of powertrain ECUs. Particulary he can choose and apply the correct approach for empirical modeling for a given powertrain calibration task (fuel consumption, emissions, air path, driveability, etc.) and type of plant (linear-nonlinear, static-dynamic, etc.). He is capable to solve typical Problems of a calibration engineer of automotive OEMs or suppliers.

Content
The efforts for the calibration of automotive powertrain ECUs are increasing due to new engine or powertrain technologies and tightening emission laws. From a present view only model based calibration methods are capable to handle this situation. The lecture presents a selection of practice-proofed model-based calibration methods.

Media
Lecture notes, blackboard, presentations and life demonstrations via projector

Course: Modeling of Thermodynamical Processes [2167523]

Coordinators: R. Schießl, U. Maas
Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Winter / Summer Term	de

Learning Control / Examinations
Oral exam
Duration: 30 min.
With attendance on exam prerequisite: 6 Credits
Without attendance on exam prerequisite: 4 Credits

Conditions
None

Recommendations
None

Learning Outcomes
After completing the course the students are able to:

- formulate thermodynamical basics in a mathematical scheme
- abstract and model complex thermodynamic processes.
- determine and implement adequate numerical schemes for the solution of the resulting systems of equations.

Content
Basics of Thermodynamics
Numerical solver strategies for algebraic equations
Optimization issues
Ordinary and partial differential equations
Application to various problems in thermodynamics (engine processes, determination of equilibrium states, unsteady processes in inhomogeneous systems)

Literature
Lecture notes
Numerical Recipes; Cambridge University Press
R.W. Hamming; Numerical Methods for scientists and engineers; Dover Books On Engineering; 2nd edition; 1973
J. Kopitz, W. Polifke; Wärmeübertragung; Pearson Studium; 1. Auflage

Course: Modern Control Concepts I [2105024]

Coordinators: J. Matthes, L. Gröll

Part of the modules: SP 40: Robotics (p. 445)[SP_40_mach], SP 04: Automation Technology (p. 409)[SP_04_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach]

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

Learning Control / Examinations
Written exam

Conditions
none

Recommendations
Measurement and control systems

Learning Outcomes
After attending the lecture, the students are able to

- Analyze linear systems with respect to various properties,
- Identify linear dynamic models,
- Design linear controllers with feedforward control in the time domain and incooperate actuator limits,
- Use Matlab for the realization of the considered concepts and
- Implement controllers in software.

Content

1. Introduction (system classes, nomenclature)
2. Equilibria
3. Linearization (software based, Hartman-Grobman-Theorem)
4. Parameter identification of linear dynamic models (SISO+MIMO)
5. PID-controller (realization, design-hints, Anti-Windup-mechanisms)
6. Conzept of 2DOF-Controllers (structure, reference signal design)
7. State space (geometric view)
8. Controller with state feedback and integrator expansion
(LQ-design, Eigenvalue placement, decoupling design)
9. Observer (LQG-design, disturbance observer, reduced observer)

Literature

- Aström, K.-J., Murray, R.M.: Feedback Systems, 2012
- Rugh, W.: Linear System Theory. Prentice Hall, 1996

Course: Modern Control Concepts II [2106032]

Coordinators: L. Gröll, J. Matthes
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 04: Automation Technology (p. 409)[SP_04_mach]

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

Learning Control / Examinations
oral exam (after lecture period)

Conditions
none

Recommendations
Modern control concepts I

Learning Outcomes
After attending the lecture, the students are able to

- Analyze and control DAE systems,
- Analyze and control systems with time delay,
- Analyze time variant systems,
- Reduce large order models and simplify complex control structures,
- Use Matlab for simulation, analysis und synthesis for applying the new concepts.

Content

1. Simulation of dynamic systems with Matlab
2. Introduction to time discrete systems
3. Differential algebraic systems (DAE)
4. Linear time variant systems (LTV)
5. Control of MIMO systems
6. Control of time delay systems
7. Internal model control (Youla parametrization)
8. Model reduction
9. Limits in control
10. Gain Scheduling

Literature
Skogestad, S.; Postlethwaite, I.: Multivariable feedback control. John Wiley & Sons, 2001

Course: Modern Control Concepts III [2106035]

Coordinators: L. Gröll
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 04: Automation Technology (p. 409)[SP_04_mach]

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

Learning Control / Examinations
Oral exam

Conditions
None.

Recommendations
Modern Control Concepts I+II, Stability theory

Learning Outcomes
After attending the lecture, the students are able to

- Analyze nonlinear systems with respect to stability,
- Design nonlinear controllers with feedforward control by different methods and
- Design basic adaptive controllers.

Content

1. Differential equations (definitions, bifurcation)
2. Feedback linearization (flatness, zero dynamics, stability)
3. Lyapunov theory
4. Overview of stability concepts
5. Backstepping design
6. Passivity based control design
7. Sliding mode control
8. Adaptive control
9. Non-Taylor based concepts for linearization

Literature
Khalil, H.K.: Nonlinear Control. Prentice Hall, 2014

Course: Engine Laboratory [2134001]

Coordinators: U. Wagner
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

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

Learning Control / Examinations
written documentation of every experiment, certificate of successful attendance, no grading

Conditions
none

Learning Outcomes
The students are abele to transfer their theoretical knowledge to practical problems and to perform engine tests on stat-of-the-art test benches.

Content
4 engine experiments in up-to-date development projects

Literature
Description of experiments

Remarks
max. 48 Participants

Course: Engine measurement techniques [2134137]

Coordinators: S. Bernhardt
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 18: Information Technology (p. 419)[SP_18_mach]

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

Learning Control / Examinations
oral examination, Duration: 0,5 hours, no auxiliary means

Conditions
None.

Recommendations
Combustion Engines I helpful

Learning Outcomes
The students are able to explain the principles of modern measuring devices and are able to determin the right device for a certain measuring problem. The are able to analyse and evaluate the results.

Content
Students get to know state-of-the-art measurement techniques for combustion engines. In particular basic techniques for measuring engine operating parameters such as torque, speed, power and temperature.

Possible measurement errors and abberations are discussed.

Furthermore techniques for measuring exhaust emissions, air/fuel ratio, fuel consumption as well as pressure indication for thermodynamic analysis are covered.

Literature
1. Grohe, H.:Messen an Verbrennungsmotoren
2. Bosch: Handbuch Kraftfahrzeugtechnik
3. Veröffentlichungen von Firmen aus der Meßtechnik
4. Hoffmann, Handbuch der Meßtechnik
5. Klingenberg, Automobil-Meßtechnik, Band C

Course: Nanotechnology for Engineers and Natural Scientists [2142861]

Coordinators: H. Hölscher, M. Dienwiebel, S. Walheim
Part of the modules: SP 47: Tribology (p. 453)[SP_47_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach]

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

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

Literature
Ausgewählte Kapitel aus

- E. L. Wolf: Nanophysik und Nanotechnologie – Eine Einführung in die Konzepte der Nanowissenschaften, Wiley-VCH (2015)
- W. Kulisch: Nanotechnologie fur Einsteiger – Herstellung und Eigenschaften von Kohlenstoff-Nanostrukturen, Wiley-VCH (2016)
- D. Natelson: Nanostructures and Nanotechnology, Cambridge University Press (2016)

Weitere Originalliteratur wird über ILIAS zur Verfügung gestellt.

Course: Nanotechnology with Clusterbeams [2143876]

Coordinators: J. Gspann
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
written examination
presence in more that 70% of the lectures
Duration: 1 h

aids: none

Conditions
None.

Learning Outcomes
Nanotechnology is presented on the basis of a technology for nano- and microstructuring by accelerated nanoparticles (clusters), mainly in view of nanomechanics.

Content
Nanotechnology in biology
Nanosystemstechnology
Cluster beam generation, ionisation and acceleration; cluster properties
Structure generation using accelerated metal clusters
Structuring via gas cluster impact; reactive accelerated cluster erosion (RACE)
Atomic force microscopy of impact structures; nanotribology
Comparison with femtosecond laser machining (Winter term only)
Simulations; Fullerene synthesis, impact structures, visionary nanomachinery

Literature
Foil copies with short commentaries are distributed during the lectures.

Course: Nanotribology and -Mechanics [2182712]

Coordinators: M. Dienwiebel
Part of the modules: SP 47: Tribology (p. 453)[SP_47_mach]

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

Learning Control / Examinations
presentation (40%) and oral examination (30 min, 60%)

no tools or reference materials

Conditions
preliminary knowlegde in mathematics and physics

Learning Outcomes
The student can

- explain the physical foundations and common models used in the field of nanotribology and nanomechanics
- describe the most important experimental methods in nanotribology
- critically evaluate scientific papers on nanotribological issues with respect to their substantial quality

Content
Part 1: Basics:

- Nanotechnology
- Forces at nanometer scale
- contact mechanics models (Hertz, JKR, DMT)
- Experimental methods (SFA, QCM, FFM)
- Prandtl-Tomlinson model
- Superlubricity
- Atomic-Scale Wear

Part 2: Topical papers

Literature
Edward L. Wolf
Nanophysics and Nanotechnology, Wiley-VCH, 2006
C. Mathew Mate
Tribology on the Small Scale: A Bottom Up Approach to Friction, Lubrication, and Wear (Mesoscopic Physics and Nanotechnology) 1st Edition, Oxford University Press
Lecture notes, slides and copies of articles

Course: Novel actuators and sensors [2141865]

Coordinators: M. Kohl, M. Sommer

Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations

(1) as core subject in the major "Microactuators and Microsensors" combined with the core subject "Micro Actuators", oral, 60 minutes
or
(2) as elective subject in the other major fields, written exam
or
(3) as optional subject, written exam

Conditions

None.

Learning Outcomes

- Knowledge of the principles of actuation and sensing including pros and cons
- Explanation of layout and function of important actuators and sensors
- Calculation of important properties (time constants, forces, displacements, sensitivity, etc.)
- Development of a layout based on specifications

Content

Contents: - Basic knowledge in the material science of actuator and sensor principles
- Layout and design optimization
- Fabrication technologies
- Selected developments
- Applications

Index: The lecture includes amongst others the following topics:

- Piezo actuators
- Magnetostrictive actuators
- Shape memory actuators
- Electro-/magnetorheological actuators
- Sensors: Concepts, materials, fabrication
- Micromechanical sensors: Pressure, force, inertia sensors
- Temperature sensors
- Micro sensors for bio analytics
- Mechano-magnetic sensors

The lecture addresses students in the fields of mechanical engineering, mechatronics and information technology, materials science and engineering, electrical engineering and economic sciences. A comprehensive introduction is given in the basics and current developments on the macroscopic length scale.
The lecture is core subject of the major course "Actuators and Sensors" of the specialization "Mechatronics and Microsystems Technology" in Mechanical Engineering.

Literature

- Lecture notes

- Donald J. Leo, Engineering Analysis of Smart Material Systems, John Wiley & Sons, Inc., 2007
- „Sensors Update“, Edited by H.Baltes, W. Göpel, J. Hesse, VCH, 1996, ISBN: 3-527-29432-5
- “Multivariate Datenanalyse – Methodik und Anwendungen in der Chemie”, R. Henrion, G. Henrion, Springer 1994, ISBN 3-540-58188-X

Course: Neutron physics of fusion reactors [2189473]

Coordinators: U. Fischer
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach]

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

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes
The aim of this lecture is to provide the neutron physics principles required for analysis of nuclear fission and fusion reactors. First of all, the basic nuclear interaction processes are presented which are important for the physical behaviour of the reactors. Next the neutron transport phenomenon in matter is described by means of the Boltzmann transport equation. Suitable mathematical solution methods are presented such as the diffusion approximation for nuclear fission reactors and the Monte Carlo method for fusion reactors. The knowledge acquired will eventually be used to solve neutron physics problems related to the design and optimization of the reactors.

Content
Nuclear interaction processes and energy release

Chain reaction and criticality

Neutron transport, Boltzmann equation

Diffusion approximation, Monte Carlo method

Neutronic reactor design

Literature
K. H. Beckurts, K. Wirtz, Neutron Physics, Springer Verlag, Berlin, Germany (1964)

W. M. Stacey, Nuclear Reactor Physics, John Wiley & Sons, Wiley-VCH, Berlin(2007)

J. Raeder (Ed.), Kontrollierte Kernfusion. Grundlagen ihrer Nutzung zur Energieversorgung, Teubner, Stuttgart (1981)

Course: Nonlinear Continuum Mechanics [2162344]

Coordinators: T. Böhlke
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 56: Advanced Materials Modelling (p. 461)[SP_56_mach]

ECTS Credits	Hours per week	Term	Instruction language
5	2	Summer term	en

Learning Control / Examinations
oral examination

Conditions
None.

Recommendations
This course is geared to MSc students.

Learning Outcomes
The students can

- derive the kinematics of finite deformations
- derive the balance laws in regular and irregular points
- discuss the principles of material theory for given examples
- evaluate the basics of fihite elasticity
- discuss the basics of elasto-plasticity
- apply basic concepts of crystal plasticity to example problems

Content

- tensor calculus, kinematics, balance equations
- principles of material theory
- finite elasticity
- infinitesimal elasto(visco)plasticity
- exact solutions ov infinitesimal Platicity
- finite elasto(visco)plasticity
- infinitesimal and finite crystal(visco)plasticity
- hardening and failure
- strain localization

Literature
lecture notes
Bertram, A.: Elasticity and Plasticity of Large Deformations - an Introduction. Springer 2005.
Liu, I-S.: Continuum Mechanics. Springer 2002.
Schade, H.: Tensoranalysis.Walter de Gruyter 1997.
Wriggers, P.: Nichtlineare Finite-Element-Methoden. Springer 2001.

Course: Nuklear Medicine and Nuklear Medicine Measurement Technics I [23289]

Coordinators: F. Maul, H. Doerfel
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Winter term	de

Learning Control / Examinations
The assessment consists of an oral exam (approx. 20 minutes) according to sec. 4 subsec. 2 no. 2 study and examination regulations.

Conditions
None.

Learning Outcomes
Die Studenten kennen den Zusammenhang zwischen klinischen Problemen und deren messtechnischen Lösung aufgrund von nuklearmedizinischen Beispielen aus der Funktionsdiagnostik und Therapie.

Content

Course: Numerical Mathematics [0187400]

Coordinators: C. Wieners, D. Weiß, Neuß, Rieder
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	de

Learning Control / Examinations
Written examination, duration 3 hours

Conditions
None.

Learning Outcomes
Die Studierenden kennen nach dieser Vorlesung die Umsetzung des im Mathematik-Modul erarbeiteten Wissens in die zahlenmäßige Lösung praktisch relevanter Fragestellungen. Dies ist ein wichtiger Beitrag zum tieferen Verständnis sowohl der Mathematik als auch der Anwendungsprobleme.

Im Einzelnen können die Studierenden

1. entscheiden, mit welchen numerischen Verfahren sie mathematische Probleme numerisch lösen können,
2. das qualitative und asymptotische Verhalten von numerischen Verfahren beurteilen und
3. die Qualität der numerischen Lösung kontrollieren.

Content
- Gleitkommarechnung
- Kondition mathematischer Probleme
- Vektor- und Matrixnormen
- Direkte Lösung linearer Gleichungssysteme
- Iterative Lösung linearer Gleichungssysteme
- Lineare Ausgleichsprobleme
- Lineare Eigenwertprobleme
- Lösung nichtlinearer Probleme: Fixpunktsatz, Newton-Verfahren
- Polynominterpolation
- Fouriertransformation (optional)
- Numerische Quadratur
- Numerische Lösung gewöhnlicher Differentialgleichungen (optional)

Literature
Elective literature:
- lecture notes (D. Weiß)
- W. Dahmen/A. Reusken: Numerik für Ingenieure und Naturwissenschaftler

Course: Numerical Modeling of Multiphase Flows [2130934]

Coordinators: M. Wörner
Part of the modules: SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 06: Computational Mechanics (p. 411)[SP_06_mach]

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

Learning Control / Examinations
Oral examination (in German or English language)
Duration: 30 minutes
Auxiliary means: none

Conditions
Bachelor

Learning Outcomes
The students can describe the physical fundamentals of multiphase flows (with focus on gas-liquid flows). The students are qualified to select for multiphase flow applications in energy and process engineering appropriate numerical methods and physical models, and to thoroughly evaluate the simulation results, so as to anaylze the specific advantages, disadvantages and restrictions of each method.

Content

1. Introduction in the subject of multi-phase flows (terms and definitions, examples)
2. Physical fundamentals (dimensionless numbers, phenomenology of single bubbles, conditions at fluid interfaces, forces on a suspended particle)
3. Mathematical fundamentals (governing equations, averaging, closure problem)
4. Numerical fundamentals (discretization in space and time, truncation error and numerical diffusion)
5. Models for interpenetrating continua (homogeneous model, algebraic slip model, standard two-fluid model and its extensions)
6. Euler-Lagrange model (particle equation of motion, particle response time, one-/two-/four-way coupling)
7. Interface resolving methods (volume-of-fluid, level-set and front-capturing method)

Literature
A brief script can be downloaded from http://bibliothek.fzk.de/zb/berichte/FZKA6932.pdf. Powerpoint presentations can be downloaded after each lecture from the ILIAS system. A list of recommended books is provided in the first lecture.

Remarks
For some topics of the lecture exercises are provided (working on them is optional).

Course: Numerical simulation of reacting two phase flows [2169458]

Coordinators: R. Koch
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

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

Learning Control / Examinations
Oral exam
Duration: approximately 30 minutes

no tools or reference materials are allowed

Conditions
None.

Recommendations
None.

Learning Outcomes
The students have the ability to:

- describe and apply the governing equations of fluid mechanics
- select and judge appropriate methods for predicting turbulent flows
- explain the procedures of numerical solver algorithms
- judge the numerical methods, on which comon CFD software is based
- judge and apply different approaches to characterize sprays
- apply methods for predicting the break up of liquids
- analyse and evaluate methods and models for the calculation of mulitphase flows
- describe reactive flows and the corresponding models

Content
The course is devoted to diploma/master students and doctoral candidates of mechanical and chemical engineering. It gives an overview of the numerical methods used for CFD of single and two phase flows. The course introduces methods for reacting single and two phase flows, as they are typically found in gas turbines and piston engines operated by liquid fuel.
1. Single phase flow: Basic equations of fluid dynamics, Turbulence: DNS, LES, RANS; Finite volume methods, Numerical solvers.

2. Two phase flows: Basics of atomisation, Characterisation of sprays, Numerical prediction of droplet movement, Numerical methods for predicitng of liquid disintegration (VoF, SPH), Numerical methods for secondary atomisation; Droplet evaporation

3. Reacting flows: Combustion models; Single droplet combustion, Spray combustion.

Literature
Lecture notes

Course: Numerical Simulation of Turbulent Flows [2153449]

Coordinators: G. Grötzbach
Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach]

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

Learning Control / Examinations
oral;

Duration: 30 minutes

no auxiliary means

Conditions
None.

Recommendations
basics in fluid mechanics

Learning Outcomes
The students are qualified to describe the fundamentals of direct numerical simulation (DNS) and large eddy simulation (LES) of turbulent flows. They understand the principle differences between these simulation methods and the respective properties of the conventional turbulence modelling approaches basing on Reynolds Averaged Navier-Stokes equations (RANS). They can describe subgrid scale models, peculiarities of wall and inlet/outlet modelling, suitable numerical solution schemes and evaluation methods. They have obtained the knowledge and understanding required to identify the best modelling approach (among the available methods) for the problem at hand, thus being able to solve given thermal and fluid dynamical problems appropriately.

Content
The lecture series will introduce in following subjects of the turbulence simulation method:

- Appearance of turbulence and deduction of requirements and limits of the simulation method.
- Conservation equations for flows with heat transfer, filtering them in time or space.
- Some subgrid scale models for small scale turbulence and their physical justification.
- Peculiarities in applying boundary and initial conditions.
- Suitable numerical schemes for integration in space and time.
- Statistical and graphical methods to analyse the simulation results.
- Application examples for turbulence simulations in research and engineering

Media
black board, plus pictures, movies, and script in English (distributed chapter by chapter)

Literature
J. Piquet, *Turbulent Flows – Models and Physics*
Springer, Berlin (2001)
G. Grötzbach, *Revisiting the Resolution Requirements for Turbulence Simulations in Nuclear Heat Transfer.*
Nuclear Engineering & Design Vol. 241 (2011) pp. 4379-4390
P. Sagaut, C. Meneveau, *Large-eddy simulation for incompressible flows: An introduction.*
Springer Verlag (2010)
G. Grötzbach,Script in English

Course: Numerical Fluid Mechanics [2153441]

Coordinators: F. Magagnato

Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
Oral examination
Duration: 30 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Learning Outcomes
The students can describe the modern numerical simulation methods for fluid flows and can explain their relevance for industrial projects. They can choose appropriate boundary and initial conditions as well as turbulence models. They are qualified to explain the meaning of suitable meshes for processed examples. Convergence acceleration techniques like multi grid, implicit methods etc. as well as the applicability of these methods to parallel and vector computing can be described by the students. They can identify problems that occur during application of these methods and can discuss strategies to avoid them. The students are qualified to become acquainted do use commercial codes like Fluent, Star-CD, CFX etc. as well as the research code SPARC. They can describe the differences between conventional methods (RANS) and more advanced approaches like Large Eddy Simulation (LES) and Direct Numerical Simulation (DNS).

Content
1. Governing Equations of Fluid Dynamics
2. Discretization
3. Boundary and Initial conditions
4. Turbulence Modelling
5. Mesh Generation
6. Numerical Methods
7. LES, DNS and Lattice Gas Methods
8. Pre- and Postprocessing
9. Examples of Numerical Methods for Industrial Applications

Media
"Powerpoint presentation", Beamer

Literature
Ferziger, Peric: Computational Methods for Fluid Dynamics. Springer-Verlag, 1999.
Hirsch: Numerical Computation of Internal and External Flows. John Wiley & Sons Inc., 1997.
Versteg, Malalasekera: An introduction to computational fluid dynamics. The finite volume method. John Wiley & Sons Inc., 1995

Course: Numerical Fluid Mechanics with MATLAB [2154409]

Coordinators: B. Frohnapfel
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

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

Learning Control / Examinations
ungraded homework

Conditions
None.

Recommendations
Lecture “Mathematical Methods of Fluid Mechanics” or “Fluid-Structure-Interaction”

Learning Outcomes
Students can solve numerically flow problems goal-oriented. They develop their own solvers for steady and unsteady flow scenarios with Matlab. The students abstract the flow problems and choose between different schemes. They are qualified to adjust relevant settings and solve the system of equations in Matlab. Furthermore, the students gain the ability to evaluate the modeling in combination with the numerical schemes. Particular knowledge in grid resolution independency, stability criteria and how to carry out a validation and verification qualifies the students to analyse und evaluate the quality of flow simulations.

Content
Numerical Fluid Mechanics with Matlab

- Introduction to Numerics and Matlab
- Finite-Difference-Method
- Finite-Volume-Method
- boundary conditions and intial conditions
- explicit and implicite schemes (Euler-forward, Euler-backward, Crank-Nicholson)
- pressure correction (SIMPLE method)

Media
Power Point, chalk board, independent programming (workstations)

Literature
H. Ferziger und M. Peri, *Numerische Strömungsmechanik*, Springer-Verlag, ISBN: 978-3-540-68228-8, 2008
E. Laurien und H. Oertel jr, *Numerische Strömungsmechanik*, Vieweg+Teubner Verlag, ISBN: 973-3-8348-0533-1, 2009
W. Dahmen und A. Reusken, *Numerik für Ingenieure und Naturwissenschaftler*, Springer-Verlag, ISBN: 978-3-540-76493-9, 2006

Remarks
Block course with limited number of participants, registration in the secretary’s office required. See details at www.istm.kit.edu

Course: Intellectual Property Rights and Strategies in Industrial Companies [2147161]

Coordinators: F. Zacharias

Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 04: Automation Technology (p. 409)[SP_04_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach]

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

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The students understand and are able to describe the basics of intellectual property, particularly with regard to the filing and obtaining of property rights. They can name the criteria of project-integrated intellectual property management and strategic patenting in innovative companies. Students are also able to describe the key regulations of the law regarding employee invention and to illustrate the challenges of intellectual properties with reference to examples.

Content
The lecture will describe the requirements to be fulfilled and how protection is obtained for patents, design rights and trademarks, with a particular focus on Germany, Europe and the EU. Active, project-integrated intellectual property management and the use of strategic patenting by technologically oriented companies will also be discussed. Furthermore, the significance of innovations and intellectual property for both business and industry will be demonstrated using practical examples, before going on to consider the international challenges posed by intellectual property and current trends in the sector.
Within the context of licensing and infringement, insight will be provided as to the relevance of communication, professional negotiations and dispute resolution procedures, such as mediation for example. The final item on the agenda will cover those aspects of corporate law that are relevant to intellectual property.
Lecture overview:

1. Introduction to intellectual property
2. The profession of the patent attorney
3. Filing and obtaining intellectual property rights
4. Patent literature as a source of knowledge and information
5. The law regarding employee inventions
6. Active, project-integrated intellectual property management
7. Strategic patenting
8. The significance of intellectual property
9. International challenges and trends
10. Professional negotiations and dispute resolution procedures
11. Aspects of corporate law

Course: Photovoltaics [23737]

Coordinators: M. Powalla
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	

Learning Control / Examinations
Turorials, written exams, alternatively oral exam.

Conditions
Basic knowledge of thermodynamics and solid state physics.

Recommendations
Complement to "Energy Systems" and "Fundamentals of Energy Technology".

Learning Outcomes
After the course attendants can:

- understand energy conversion in semiconductors.
- discuss emerging technological and production relevant aspects.
- capture the interaction of photovoltaic energy sytems with different system components.
- quantify losses.

Content

- The significance of photovoltaics in national and global energy supply.
- Physical fundamentals of energy conversion.
- Photovoltaic cells (specific parameters, materials, loss assessment).
- Implementation concepts (Sillicon technology, thin layer cells, concentrator cells, dye cells and organic cells).
- Modular technique and production technology.
- Photovoltaic energy systems (Components, alternative current converter, solar tracking, system design).

Literature
P. Würfel, Physik der Solarzellen, 2. Auflage (Spektrum Akademischer Verlag, Heidelberg, 2000)
R. Sauer, Halbleiterphysik, (Oldenburg Wissenschaftsverlag, 2009)
H.J. Lewerenz, H. Jungblut, Photovoltaik (Springer, Berlin, 1995)
H.G. Wagemann, Photovototaik, (Vieweg, Wiebaden, 2010)
Tom Markvart, Luis Castaner, Photovoltaics Fundamentals and Applications, (Elsevier, Oxford, 2003)
Heinrich Häberlin, Photovoltaik, (AZ Verlag, Aarau, 2007)

Course: Photovoltaic Systems Technology [23380]

Coordinators: N. N.
Part of the modules: SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	de

Learning Control / Examinations
The assessment consists of an oral exam (20 min) taking place at the beginning of the recess period (according to Section 4 (2), 2 of the examination regulation). The exam takes place in every summer semester. Re-examinations are offered at every ordinary examination date.

Conditions
None.

Learning Outcomes
Students know the theoretical fundamentals of photovoltaic systems technology.

Content

- Introduction
- Ways of solar energy utilisation
- The terrestrial solar radiation
- Solar radiation measuring principles
- Fundamentals of solar cells
- Overview of typical cell technologies
- Efficiency values
- Equivalent circuit diagram of solar cells
- Properties of solar cells and solar modules
- Series and parallel connection of solar cells
- Matching of solar generators and loads
- MPP-Tracking
- Construction of PV-modules
- Partial shading, bypass-technologies
- Overview of different System configurations
- Batteries for PV applications
- Charge controllers
- Battery peripherals
- Inverters for stand-alone systems
- Inverters for grid connected systems
- European efficiency
- Safety and EMC aspects
- Annual yield of PV systems

- Economic evaluation of PV systems
- Examples of realised PV systems

Media
Copies of the main transparenvies will be distributed each lecture.

Literature
Elective literature:
„Regenerative Energiesysteme“, Volker Quaschning, ISBN: 978-3-446-40973-6
„Photovoltaik“, Heinrich Häberlin, ISBN:978-3-8007-3003-2

Course: Physical and chemical principles of nuclear energy in view of reactor accidents and back-end of nuclear fuel cycle [2189906]

Coordinators: R. Dagan, Dr. Volker Metz
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Winter term	de

Learning Control / Examinations
oral exam, 20 min.

Conditions
None

Recommendations
None

Learning Outcomes
The students

- understand the physical explanations of the known nuclear accidents
- can perform simplified calculations to demonstrate the accidents outcome.
- Define safety relevant properties of low/ intermediate / high level waste products
- Are able to evaluate principles and implications of reprocessing, storage and disposal options for nuclear waste.

Content

- Relevant physical terms of nuclear physics
- Decay heat removal- Borst-Wheeler equation
- The accidents in TMI- Three Mile Island, and Fukushima .
- Fission , chain reaction and reactor control systems
- Basics of nuclear cross sections
- Principles of reactor dynamics
- Reactor poisoning
- The Idaho and Chernobyl accidents
- Principles of the nuclear fuel cycle
- Reprocessing of irradiated fuel elements and vitrification of fission product solutions
- Interim storage of nuclear residues in surface facilities
- Multi barrier concepts for final disposal in deep geological formations
- The situation in the repositories Asse II, Konrad and Morsleben

Literature
AEA- Open documentation of the reactor accidents
K. Wirtz: Basics of Reactor technic Par I, II, Technic School Karlsruhe 1966 (in German)
D. Emendorfer. K.H. Höcker: Theory of nuclear reactions, Parts I, II BI- Hochschultaschenbücher 1969 (in German)
J. Duderstadt and L. Hamilton: Nuclear reactor Analysis, J. Wiley $ Sons , Inc. 1975.
R.C. Ewing: The nuclear fuel cycle: a role for mineralogy and geochemistry. Elements vol. 2, p.331-339, 2006
J. Bruno, R.C. Ewing: Spent nuclear fuel. Elements vol. 2, p.343-349, 2006

Course: Planning of Assembly Systems (in German) [2109034]

Coordinators: E. Haller
Part of the modules: SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach], SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
Elective Subject: oral exam (approx. 30 min)
Optional Subject: oral exam (approx. 30 min)
The exam is offered in German only!

Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required
- Compulsory attendance during the whole lecture

Recommendations

- Knowledge of Human Factors Engineering or Production Management/Industrial Engineering helpful

Learning Outcomes
The students

- know planning guidelines
- know vulnerability analysis
- are able to plan work systems (e.g. technical or organisational structuring principles, capacity planinng, proceedence diagram, payment system)
- are able to evaluate a planning solution
- are able to present results

Content

1. Planning guidelines
2. Vulnerability analysis
3. Planning of work systems (technical and organisational structuring principles, capacity planning, proceedence diagram, payment system)
4. Evaluation
5. Presentation

Literature
Handout and literature online ILIAS.

Course: Multi-scale Plasticity [2181750]

Coordinators: K. Schulz, C. Greiner
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach]

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

Learning Control / Examinations
presentation (40%), oral examination (30 min, 60%)

Conditions

- limited number of participants
- mandatory registration
- mandatory attendance

Recommendations
preliminary knowlegde in mathematics, physics, mechanics and materials science

Learning Outcomes
The student

- can explain the physical foundations of plasticity as well as results of latest research.
- can independently read and evaluate scientific research papers.
- can present specific, technical information in structured, precise, and readable manner.
- is able to argue for and/or against a particular approach or idea using the knowledge acquired within the lecture.

Content
This module will attempt to provide an overview to complex subjects in the field of material mechanics. For this purpose important scientific papers will be presented and discussed.
This will be done by having students read and critique one paper each week in a short review. In addition, each week will include presentation from one of the participants which aim to advocate or criticise each piece of work using the short reviews. He will also be the discussion leader, while students discuss the content, ideas, evaluation and open research questions of the paper. Using a professional conference management system (HotCRP), the student assume the role of reviewers and gain insight into the work of researchers.

Media
black board, beamer, script

Remarks
The maximum number of students is 14 per semester.

Course: PLM for Product Development in Mechatronics [2122376]

Coordinators: M. Eigner
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

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

Learning Control / Examinations
The assessment consists of an oral exam (30 min.).

Conditions
None.

Learning Outcomes
Students have a basic overview about product data management and product lifecycle management.
Students know components and core functions of PLM solutions
Students can describe trends in research and practice in the environment of PLM

Content
Product Data Management
Product Lifecycle Management

Course: PLM in the Manufacturing Industry [2121366]

Coordinators: G. Meier
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
Oral group examination, Duration 1 hour, Auxiliary Means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
Students know essential aspects of PLM Processes which are exemplarily introduced with examples form Heidelberger Druckmaschinen.
Students know objects of the PLM Process and know the interconnection between CAD and PLM.
Students understand the procedure of PLM-installation in an industrial enterprise and occurring challenges concerning strategy, vendor selection and psychology.
They are able to create installation concepts for PLM systems in the scope of team exercises and explain the approaches in presentations.

Content
A description of systematic requirement engineering is given, based on the introduction of PLM-Processes and (Multi-) Project management in the product development process. By the introduction of a PLM-Project, Objects of the PLM Process like material master, bill of material, documents and classifications are explained. Furthermore a 3D-Process chain is introduced to show the implementation of technical modifications. Finally, specific aspects of the mechatronic development are introduced.

Literature
Lecture slides

Course: Polymer Engineering I [2173590]

Coordinators: P. Elsner
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 36: Polymer Engineering (p. 442)[SP_36_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 47: Tribology (p. 453)[SP_47_mach]

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

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
None.

Learning Outcomes
The field of Polymer Engineering includes synthesis, material science, processing, construction, design, tool engineering, production technology, surface engineering and recycling. The aim is, to equip the students with knowledge and technical skills, and to use the material “polymer” meeting its requirements in an economical and ecological way.
The students

- are able to describe and classify polymers
  based on the fundamental synthesis processing techniques
- can find practical applications for state-of-the-art polymers and manufacturing technologies
- are able to apply the processing techniques, the application of polymers and polymer composites regarding to the basic principles of material science
- can describe the special mechanical, chemical and elctrical prooperties of polymers and correlate these properties to the chemical bindings.
- can define application areas and the limitation in the use of polymers

Content
1. Economical aspects of polymers
2. Introductiom of mechanical,
chemical end electrical properties
3. Processing of polymers
(introduction)
4. Material science of polymers
5. Synthesis

Literature
Recommended literature and selected official lecture notes are provided in the lecture

Course: Polymer Engineering II [2174596]

Coordinators: P. Elsner
Part of the modules: SP 36: Polymer Engineering (p. 442)[SP_36_mach]

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

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
None.

Recommendations
Knowledge in Polymerengineering I

Learning Outcomes
The field of Polymer Engineering includes synthesis, material science, processing, construction, design, tool engineering, production technology, surface engineering and recycling. The aim is, that the students gather knowledge and technical skills to use the material "polymer" meeting its requirements in an economical and ecological way.
The students

- can describe and classify different processing techniques
  and can exemplify mould design principles based on technical parts.
- know about practical applications and processing of polymer parts
- are able to design polymer parts according to given restrictions
- can choose appropriate polymers based on the technical requirements
- can decide how to use polymers regarding the production, economical and ecological requirements

Content
1. Processing of polymers
2. Properties of polymer components
Based on practical examples and components
2.1 Selection of material
2.2 Component design
2.3 Tool engineering
2.4 Production technology
2.5 Surface engineering
2.6 Sustainability, recycling

Literature
Recommended literature and selected official lecture notes are provided in the lecture

Course: Polymers in MEMS A: Chemistry, Synthesis and Applications [2141853]

Coordinators: B. Rapp
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Bachelor students with basic knowledge in material science and chemistry. The lecture will cover all the basics required for understanding the organic chemistry so detailed previous knowledge is not required. Basic understanding of MEMS and its technologies is helpful but not mandatory.

Learning Outcomes
The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge required for understanding what polymers are and how they are made, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.
After attending the lecture the students will be able:

- ... to understand the physic/chemical basics of organic chemistry in polymer synthesis.
- ... to state the most important polymers and polymer classes and to develop application examples for these.
- ... to state the most important polymers in MEMS.
- ... to understand the most important techniques for rapid prototyping.
- ... to state and to understand the most important resists in MEMS.
- ... to understand the chemical synthesis of polymers.

... to correctly estimate the application scope of the individual classes of polymers.

Content
We all come in contact with numerous polymeric products in everyday life. From water bottles to packaging to the cover of the iPad, many things are made of polymers. Polymers are also important materials for modern microelectromechanical systems (MEMS) allowing cost effective mass market compatible products, e.g., in the life sciences or diagnostics. But polymers are not just cost-effective replacements for more expensive classical materials in MEMS (such as, e.g., silicon) – some polymers have intrinsic properties that make them ideal materials for sensors, actuators or templates for biology and chemistry in MEMS.
This lecture will introduce the basics of organic chemistry required for understanding what polymers are, how they are manufactured and which mechanisms are responsible for their unique properties. The lecture will highlight (in the context of MEMS but also in a wider scope) where and why polymers are applied with a strong focus on their chemical and physical properties (and on their synthesis).
Some of the topics covered are:

- What is the basic chemistry of polymers? What are monomers, what are macromolecules and how are they formed?
- How are polymers produced on industrial scale – but also on the laboratory scale? Numerous examples of how to make (commonly and lesser known) polymers will be discussed including materials such as Plexiglas.
- Why are polymers so important for biochemistry and tissue engineering?
- How do photoresists work and why do some polymers contract when exposed to light?
- What are high-performance polymers and why do they have such a wide application range, e.g., in implants?

- What polymers fuel the household 3D printing community and what materials do 3D printers such as, e.g., the RepRap work with?
- How does 3D printing and rapid prototyping work and which polymers can be employed for which techniques?
- Why does silicone always smell like vinegar and why is this material so important for modern day microfluidics? How do you built fluid-logic devices using silicone?
- How do shape memory polymers remember their shape?
- What are polymer foams and why are they not only important for heat insulation but also for organic chemistry?
- How do glues work? Why are there two-component glues, what is superglue and how can you make glue from potatoes?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.
For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu). Preregistration is not necessary.

Media
The lecture slides will be given out as scriptum during each lecture course.

Remarks
For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu). Preregistration is not necessary.

Course: Polymers in MEMS B: Physics, Microstructuring and Applications [2141854]

Coordinators: M. Worgull
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Bachelor students with basic knowledge in material science and mechanical engineering. The lecture will cover all the basics required for understanding. Detailed knowledge of microsystem technology and it's processes is helpful but not mandatory.

Learning Outcomes
The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge required for understanding what polymers are and how they are made, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.
After attending the lecture the students will be able:

- ... to understand the properties of polymers as a consequence of their morphology.
- ... to describe the most important structuring techniques and technologies for polymers in MEMS.
- ... to understand the mathematical basis of the most important physical models for polymers.
- ... to correctly judge polymer properties and the applicability of the polymers for their industrial processability.
- ... to understand the basics of process simulation in polymer structuring.
- ... to state the most important technical thermoplasts in MEMS and to understand their properties.
- ... to correctly classify the various types of polymers, blends, composite materials.

Content
We all come in contact with numerous polymeric products in everyday life. From water bottles to packaging to the cover of the iPad, many things are made of polymers. Polymers are also important materials for modern microelectromechanical systems (MEMS) allowing cost effective mass market compatible products, e.g., in the life sciences or diagnostics. But polymers are not just cost-effective replacements for more expensive classical materials in MEMS (such as, e.g., silicon) – some polymers have intrinsic properties that make them ideal materials for sensors, actuators or templates for biology and chemistry in MEMS.
This lecture will introduce the basics of physics and material science required for the understanding of the mechanical behavior seen from the engineers view. Micro and nanostructuring of polymers allows the fabrication of micro parts fulfilling their tasks in mostly invisible different applications. But also the fabrication of polymer parts with functional surfaces inspired from Bionics will be presented in this lesson. The lesson will give further an overview over the polymer based structuring processes and will underline the importance by a number of applications e.g. photonic structures or Lotus-like structures.
Some of the topics covered are:

- How can polymers described from the view of engineers?
- What are the differences between polymers and metals?
- Rheology of polymer melts – How does polymer melts flow?
- How can polymers be formed and demolded?
- Which structuring processes (replication) processes are available?

- How does stress influence molded parts (e.g. the deformation of a CD in a hot car)
- Shrinkage of polymers – which precision is achievable
- Gluing or welding – How can polymers be assembled?
- Simulation of replication processes
- Characterization of polymers – which properties can be measured?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.
For further details, please contact the lecturer, PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

Media
The lecture slides will be given out as scriptum during each lecture course.

Remarks
For further details, please contact the lecturer, PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

Course: [2142855]

Coordinators: M. Worgull, B. Rapp
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Bachelor students with basic knowledge in material science and chemistry. Basic understanding of MEMS and its technologies is helpful but not mandatory. Students should also have attended either "Polymers in MEMS A" or "Polymers in MEMS B" during winter semester as this lecture will not provide a general introduction in the chemistry of polymers or polymer processing.

Learning Outcomes
The aim of the lecture is providing mechanical or chemical engineers, as well as interested students from the life or material sciences the basic knowledge of biopolymers and bioplastics, highlighting their importance for modern MEMS systems with a wide view to applications in everyday life.
After attending the lecture the students will be able:

- ... to correctly classify biopolymers and bioplastics.
- ... to correctly state their properties, advantages and disadvantages.
- ... to correctly estimate their application scope in MEMS.
- ... to understand their usage in everyday life.
- ... to correctly judge their sustainability.
- ... to develop further applications of this class of materials.

... to correctly estimate the suitability of biopolymers and bioplastics, especially compared to conventionally polymers.

Content
Polymers are ubiquitous in everyday life: from packaging materials all the way to specialty products in medicine and medical engineering. Today it is difficult to find a product which does not (at least in parts) consist of polymeric materials. The question of how these materials can be improved with respect to their disposal and consumption of (natural) resources during manufacturing is often raised. Today polymers must be fully recycled in Germany and many other countries due to the fact that they do not (or only very slowly) decompose in nature. Furthermore significant reductions of crude oil consumption during synthesis are of increasing importance in order to improve the sustainability of this class of materials. With respect to disposal polymers which do not have to be disposed by combustion but rather allow natural decomposition (composting) are of increasing interest. Polymers from renewable sources are also of interest for modern microelectromechanical systems (MEMS) especially if the systems designed are intended as single-use products.
This lecture will introduce the most important classes of these so-called biopolymers and bioplastics. It will also discuss and highlight polymers which are created from naturally created analogues (e.g. via fermentation) to petrochemical polymer precursors and describe their technical processing. Numerous examples from MEMS as well as everyday life will be given.
Some of the topics covered are:

- What are biopolyurethanes and how can you produce them from castor oil?
- What are "natural glues" and how are they different from chemical glues?
- How do you make tires from natural rubbers?

- What are the two most important polymers for life on earth?
- How can you make polymers from potatoes?
- Can wood be formed by injection molding?
- How do you make buttons from milk?
- Can you play music on biopolymers?
- Where and how do you use polymers for tissue engineering?
- How can you built LEGO with DNA?

The lecture will be given in German language unless non-German speaking students attend. In this case, the lecture will be given in English (with some German translations of technical vocabulary). The lecture slides are in English language and will be handed out for taking notes. Additional literature is not required.
For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu) and PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

Literature
Additional literature is not required.

Remarks
For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu) and PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is not necessary.

Course: [2142856]

Coordinators: M. Worgull, B. Rapp
Part of the modules: SP 33: Microsystem Technology (p. 439)[SP_33_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	de

Learning Control / Examinations
The practical course will close with an oral examination.There will be only passed and failed results, no grades.

Conditions
Having attended either “Polymers in MEMS A” or “Polymers in MEMS B” is a prerequisite for this practical course. For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu) and PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is mandatory. The number of participants is limited to 5 students.

Recommendations
Bachelor (or equivalent level) students with basic knowledge in material science and chemistry. Students must have attended either “Polymers in MEMS A” or “Polymers in MEMS B” during winter semester.

Learning Outcomes
The practical course will provide mechanical or chemical engineers, as well as interested students from the life or material sciences a deeper understanding of polymers, their synthesis and their processing.
After attending the lecture the students will be able:

- . . . to synthesize relevant polymers on a laboratory scale.
- . . . to characterize these materials.
- . . . to structure these polymers.

. . . to use these polymers in exemplary MEMS applications..

Content
This practical course complements the lectures “Polymers in MEMS A”, “Polymers in MEMS B” and “Polymers in MEMS C” and will allow students to gain a deeper understanding of polymers and their processing. During the course of this practical course, various polymers will be synthesized and molded into components suitable for microelectromechanical systems (MEMS) applications. The aim of the course is to bring a polymer all the way from synthesis to application.
The practical course will be given in German language unless non-German speaking students attend. In this case, the course will be given in English (with some German translations of technical vocabulary). Lecture notes for the experiments are in English language and will be handed out to the students. The practical course will be held “en block” at the end of the semester (presumably beginning of October)
For further details, please contact the lecturer, Dr. Ing. Bastian E. Rapp (bastian.rapp@kit.edu) and PD Dr.-Ing. Matthias Worgull (matthias.worgull@kit.edu). Preregistration is mandatory. The number of participants is limited to 5 students.

Media
descriptions of the experiments

Literature
Scripts of the corresponding lectures, further literature as named there.

Course: Laboratory “Laser Materials Processing” [2183640]

Coordinators: J. Schneider, W. Pfleging
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
The assessment consists of a colloquium for every single experiment and an overall final colloquium incl. an oral presentation of 20 min.

Conditions
None.

Recommendations
Basic knowledge of physics, chemistry and material science is assumed.
The attendance to one of the courses Physical Basics of Laser Technology (2181612) or Laser Application in Automotive Engineering (2182642) is strongly recommended.

Learning Outcomes
The student

- can describe the influence of laser, material and process parameters and can choose suitable parameters for the most important methods of laser-based processing in automotive engineering.
- can explain the requirements for safe handling of laser radiation and for the design of safe laser systems.

Content
The laboratory compromises 8 half-day experiments, which address the following laser processing topics of metals, ceramics and polymers:
• safety aspects
• surface hardening and remelting
• melt and reactive cutting
• surface modification by dispersing or alloying
• welding
• surface texturing
• metrology
There are used CO_2-, excimer-, Nd:YAG- and high power diode-laser sources within the laboratory.

Media
lecture notes via ILIAS

Literature
W.T. Silfvast: Laser Fundamentals, 2008, Cambrigde University Press
W.M. Steen: Laser Materials Processing, 2010, Springer

Remarks
The maximum number of students is 12 per semester.

Course: Lab Computer-aided methods for measurement and control [2137306]

Coordinators: C. Stiller, M. Spindler
Part of the modules: SP 18: Information Technology (p. 419)[SP_18_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 04: Automation Technology (p. 409)[SP_04_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach]

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

Learning Control / Examinations
Colloquia

Conditions
None.

Recommendations
Basic studies and preliminary examination; basic lectures in automatic control

Learning Outcomes
Powerful and cheap computation resources have led to major changes in the domain of measurement and control. Engineers in various fields are nowadays confronted with the application of computer-aided methods. This lab tries to give an insight into the modern domain of measurement and control by means of practically oriented and flexible experiments. Based on experiments on measurement instrumentation and digital signal processing, elementary knowledge in the domain of visual inspection and image processing will be taught. Thereby, commonly used software like MATLAB/Simulink will be used in both simulation and realization of control loops. The lab closes with selected applications, like control of a robot or supersonic computer tomography.

Content
1. Digital technology
2. Digital storage oscilloscope and digital spectrum analyzer
3. Supersonic computer tomography
4. Lighting and image acquisition
5. Digital image processing
6. Image interpretation
7. Control synthesis and simulation
8. Robot: Sensors
9 Robot: Actuating elements and path planning
The lap comprises 9 experiments.

Literature
Instructions to the experiments are available on the institute's website

Course: Practical Course “Tribology” [2182115]

Coordinators: J. Schneider, M. Dienwiebel
Part of the modules: SP 47: Tribology (p. 453)[SP_47_mach]

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

Learning Control / Examinations
The assessment consists of a colloquium for every single experiment and an overall final colloquium incl. an oral presentation of 20 min.

Conditions
none

Recommendations
The attendance to one of the course Tribology (2181114) is strongly recommended!

Learning Outcomes
The student

- knows the most common methods of friction and wear measurement
- knows the most common tribological model tests for the characterization of materials under sliding, rolling and abrasive conditions
- can carry out a tribological system analysis and based on that derive suitable loading parameters for model tests

Content
The laboratory compromises five full-day experiments, which address the following topics:

- tribological system analysis
- basics of tribological measurement techniques
- topographical surface characterization
- tribological model tests under sliding, rolling and abrasive conditions
- microscopical characterization of worn surfaces

Media
lecture notes via ILIAS

Literature
H. Czichos, K.-H. Habig: Tribologie-Handbuch. Vieweg + Teubner Verlag, Wiesbaden, 2010 (http://www.springerlink.com/conte
K. Sommer, R. Heinz, J. Schöfer: Verschleiß metallischer Werkstoffe: Erscheinungsformen sicher beurteilen. Vieweg + Teubner Verlag, Wiesbaden, 2010 (http://www.springerlink.com/content/u24843/#section=806215&page=1)
Gesellschaft für Tribologie e.V. (GFT): Arbeitsblatt 7: Tribologie – Verschleiß, Reibung: Definitionen, Begriffe, Prüfung. GFT, Moers, 2002. (Download unterwww.gft-ev.de/arbeitsblaetter.htm)
K.-H. Zum Gahr: Microstructure and wear of materials. Elsevier, Amsterdam, 1987.

Remarks
The maximum number of students is 12.
registration via Email to johannes.schneider@kit.edu

Course: Practical Course Technical Ceramics [2125751]

Coordinators: R. Oberacker
Part of the modules: SP 43: Technical Ceramics and Powder Materials (p. 449)[SP_43_mach]

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

Learning Control / Examinations
Colloquium and laboratory report for the respective experiments.

Conditions
None.

Recommendations
Courses in ceramic materials

Learning Outcomes
The students are able to understand and to apply a number of basic laboratory methods used in processing and characterization of ceramic materials. They are qualified to apply new methods on the basis of standards and descriptions of experiments.

Content
Major test methods for the characterization of raw materials, intermediate and final products of ceramic materials are practically applied. Topics:

- Shaping of powder compacts
- sintering
- microstructural characterization
- mechanical testing

On the basis of short descriptions of the methods, the students prepare themselfes, carry out the experiments and write a laboratory report.

Media
Slides for the practical:
available under http://ilias.studium.kit.edu

Literature
Salmang, H.: Keramik, 7. Aufl., Springer Berlin Heidelberg, 2007. - Online-Ressource

Richerson, D. R.: Modern Ceramic Engineering, CRC Taylor & Francis, 2006

Course: Workshop on computer-based flow measurement techniques [2171488]

Coordinators: H. Bauer
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach]

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

Learning Control / Examinations
Group colloquia for each topic

Duration: approximately 10 minutes

no tools or reference materials may be used

Conditions
none

Learning Outcomes
The students are able to:

- theoretically describe and explain the fundamentals of computer aided measurements and and adopt them practically
- apply the basics learned during the lecture to a practical problem in the form of a PC excercise

Content
The laboratory course offers an introduction into the acquisition of basic test data in fluid mechanics applications as well as a basic hands-on training for the application of modern PC based data acquisition methods. The combination of lectures about measurement techniques, sensors, signal converters, I/O systems, bus systems, data acquisition, handling and control routines and tutorials for typical fluid mechanics applications allows the participant to get a comprehensive insight and a sound knowledge in this field. The graphical programming environment LabVIEW from National Instruments is used in this course as it is one of the standard software tools for data acquisition worldwide.
Basic design of measurements systems

- Logging devices and sensors
- Analog to digital conversion
- Program design and programming methods using LabView
- Data handling
- Bus systems
- Design of a computer aided data acquisition system for pressure, temperature and derived parameters
- frequency analysis

Literature
Germer, H.; Wefers, N.: Meßelektronik, Bd. 1, 1985
LabView User Manual
Hoffmann, Jörg: Taschenbuch der Messtechnik, 6., aktualisierte. Aufl. , 2011

Course: Practical course: Humanoid Robots [24890]

Coordinators: T. Asfour
Part of the modules: SP 40: Robotics (p. 445)[SP_40_mach]

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

Learning Control / Examinations

Conditions

None.

Learning Outcomes

Content

Course: Laboratory Production Metrology [2150550]

Coordinators: B. Häfner
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 04: Automation Technology (p. 409)[SP_04_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach]

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

Learning Control / Examinations
Alternative test achievement - Group presentation

Conditions
None.

Learning Outcomes
The students . . .
• are able to name, describe and mark out different measurement technologies that are relevant in a production environment.
• are able to conduct measurements with the presented in-line and laboratory based measurement systems.
• are able to analyze measurement results and asses the measurement uncertainty of these.
• are able to deduce wether a work piece fullfills quality relevant specifications by analysing measurement results.
• are able to use the presented measurement technologies for a new task.

Content
During this course, students get to know measurement systems that are used in a production system. In the age of Industry 4.0, sensors are becoming more important. Therefore, the application of in-line measurement technology such as machine vision and non-destructive testing is focussed. Additionally, laboratory based measurement technologies such as computed tomography are addressed. The student learn the theoretical background as well as practical applications for industrial examples. The students use sensors by themselves during the course. Additionally, they are trained on how to integrate sensors in production processes and how to analyze measurement data with suitable software. The following topics are addressed:
- Classification and examples for different measurement technologies in a production environment
- Machine vision with optical sensors
- Information fusion based on optical measurements
- Robot-based optical measurements
- Non-destructive testing by means of acoustic measurements
- Coodinate measurement technology
- Industrial computed tomography
- Measurement uncertainty evaluation
- Analysis of production data by means of data mining

Media
Lecture notes will be provided in Ilias (https://ilias.studium.kit.edu/). Additional reference to literature will be provided, as well.

Course: Introduction to Microsystem Technology - Practical Course [2143875]

Coordinators: A. Last
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach], SP 33: Microsystem Technology (p. 439)[SP_33_mach]

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

Learning Control / Examinations
written exam

Conditions
None.

Learning Outcomes

- Deepening of the contents of the lecture MST I and II.
- Understanding the technological processes in micro system technology.
- Experience in lab-work at real workplaces where research is normally carried out.

Content
The practical training includes eleven experiments:
1. Hot embossing of plastic micro structures
2. Micro electroforming
3. X-ray optics
4. UV-lithography
5. Optical waveguides
6. Capillary electrophoresis on a chip
7. SAW bio sensor
8. Atomic force microscopy
9. Micro mixer unit
10. Additive prototyping of micro structures
11. Combinatorial laser-induced forward transfer (cLIFT)

Each student participates in a total of five experiments which are automatically assigned.
The experiments are carried out at real workstations at the IMT and coached by IMT-staff.

Literature
W. Menz, J. Mohr, O. Paul
Microsystem Technology,
Wiley-VCH, Weinheim 2005

Course: Principles of Whole Vehicle Engineering II [2114860]

Coordinators: R. Frech
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	en

Learning Control / Examinations

Conditions

Can not be combined with lecture [2114842] “Grundsätze der PKW-Entwicklung II”.

Learning Outcomes

Content

Course: Product Lifecycle Management [2121350]

Coordinators: J. Ovtcharova, T. Maier
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

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

Learning Control / Examinations
written examination
Duration:
1,5 hours

Auxiliary Means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can:

- clarify the management concept of PLM, its objectives and highlight the economic benefits of the PLM concept.
- illustrate the need for an integrated and cross-departmental business process - from planning, portfolio construction and return of customer information, from the use phase to maintenance and recycling of products.
- reason the processes and functions needed to support the entire product life cycle and discuss the main operating software systems (PDM, ERP, SCM, CRM) and their functions for supporting PLM.
- argue a method to successfully introduce the concept of Management PLM in companys.

Content
Product Lifecycle Management (PLM) is an approach to the holistic and cross-company management and control of all product-related processes and data throughout the life cycle along the extended supply chain - from design and production to sales, to the dismantling and recycling.
Product Lifecycle Management is a comprehensive approach for effective and efficient design of the product life cycle. Based on all product information, which comes up across the entire value chain and across multiple partners, processes, methods and tools are made available to provide the right information at the right time, quality and the right place.
The course covers:

- A consistent description of all business processes that occur during the product life cycle (development, production, sales, dismantling, ...)
- the presentation of methods for the performance of the PLM business processes,
- explaining the most important corporate information systems to support the life cycle (PDM, ERP, SCM, CRM systems) to sample the software manufacturer SAP

Literature
Lecture slides.

V. Arnold et al: Product Lifecycle Management beherrschen, Springer-Verlag, Heidelberg, 2005.

J. Stark: Product Lifecycle Management, 21st Century Paradigm for Product Realisation, Springer-Verlag, London, 2006.

A. W. Scheer et al: Prozessorientiertes Product Lifecycle Management, Springer-Verlag, Berlin, 2006.

J. Schöttner: Produktdatenmanagement in der Fertigungsindustrie, Hanser-Verlag, München, 1999.

M.Eigner, R. Stelzer: Produktdaten Management-Systeme, Springer-Verlag, Berlin, 2001.

G. Hartmann: Product Lifecycle Management with SAP, Galileo press, 2007.

K. Obermann: CAD/CAM/PLM-Handbuch, 2004.

Course: Product, Process and Resource Integration in the Automotive Industry [2123364]

Coordinators: S. Mbang
Part of the modules: SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
Oral examination, Durations: 20 min, Auxiliary Means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
A considerable aspect of this lecture is to combine engineering knowledge with the practical, real industrial problems and applications.
Thus, the objectives of the lecture are:

- collaborative drafting of industrial and academic state of the art regarding the basics.
- specification of exigencies, requirements and concepts for an integrated CAx-process chain,
- introduction in the paradigms of the integrated process-oriented product development
- to convey practical industrial knowledge about the integrated product development in the automotive sector

Content
The lecture

- Overview of product development in the automotive sector (process- and work cycle, IT-Systems)
- Integrated product models in the automotive industry (product, process and resource)
- New CAx modeling methods (intelligent feature technology, templates & functional modeling)
- Automation and knowledge-based mechanism for product design and production planning
- Product development in accordance with defined process and requirement (3D-master principle, tolerance models)
- Concurrent Engineering, shared working
- Enhanced concepts: the digital and virtual factory (application of virtual technologies and methods in the product development)
- Systems: CAD/CAM modeling (CATIA V5), planning (CATIA/DELMIA), archiving – PDM (CATIA/SmarTeam).

Additionally, A practical industrial project study is offered, which is based on an integrated application scenario (from design of production resources, over testing and validation method planning to the manufacturing and implementation of the production resources).
Since the student will be divided in small teams, this study will also teach the students about team word and distributed development.

Literature
Lecture slides

Remarks
Max. 20 students, registration necessary (ILIAS)

Course: Production and Logistics Controlling [2500005]

Coordinators: H. Wlcek
Part of the modules: SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

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

Conditions
None.

Recommendations
See German version.

Learning Outcomes
See German version.

Content
See German version.

Course: Production Planning and Control [2110032]

Coordinators: A. Rinn
Part of the modules: SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach], SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
Elective Subject: oral exam (approx.. 30 min)
Optional Subject: oral exam (approx. 30 min)
The exam is offered in German only!

Conditions

- Compact course
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required
- Compulsory attendance during the whole lecture

Recommendations

- Knowledge in Production Management/Industrial Engineering is required
- Knowledge of Work Science and Economics is helpful
- Knowledge of Informatics is not required, but helpful

Learning Outcomes

- Gain deeper insight within production management
- Increase knowledge of production planning and control
- Understand realistic practical aspects
- Understand basic techniques for the modelling and the simulation of production systems

Content

1. Practical application of PPC-methods
2. Goals and recommanditions for production planning and control
3. Strategies for work control
4. Case study: Manufacturing of bicycles
5. Simulation of a bicycle factory for the production planning and control
6. Simulation of the order processing
7. Decision making about order control and procurement of purchased parts
8. Evaluation of the simulation protocols
9. Realisation of production planning and control

Literature
Handout and literature are available on ILIAS for download.

Course: Production Techniques Laboratory [2110678]

Coordinators: K. Furmans, J. Ovtcharova, V. Schulze, B. Deml, Research assistants of wbk, ifab und IFL
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

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

Learning Control / Examinations
Advanced Internship: Participate in practicle exercise courses and complete the colloquia successfully.
Elective Subject: Participate in practicle exercise courses and complete the colloquia successfully and presentation of a specific topic.
Optional Subject: Participate in practicle exercise courses and complete the colloquia successfully and presentation of a specific topic.

Conditions
None.

Recommendations
Participation in the following lectures:

- Informationssystems in logistics and supply chain management
- Material flow in logistic systems
- Manufacturing technology
- Human Factors Engineering

Learning Outcomes
The students acquire in the lab profound knowledge about the scientific theories, principles and methods of Production Engineering. Afterwards they are able to evaluate and design complex production systems according to problems of manufacturing and process technologies, materials handling, handling techniques, information engineering as well as production organisation and management.
After completion this lab, the students are able

- to analyse and solve planning and layout problems of the discussed fields,
- to evaluate and configure the quality and efficiency of production, processes and products,
- to plan, control and evaluate the production of a production enterprise,
- to configure and evaluate the IT architecture of a production enterprise,
- to design and evaluate appropriate techniques for conveying, handling and picking within a production system,
- to design and evaluate the part production and the assembly by considering the work processes and the work places.

Content
The production technique laboratory (PTL) is a collaboration of the institutes wbk, IFL, IMI and ifab.

1. Computer Aided Product Development (IMI)
2. Computer communication in factory (IMI)
3. Production of parts with CNC turning machines (wbk)
4. Controlling of production systems using PLCs (wbk)
5. Automated assembly systems (wbk)

6. Optical identification in production and logistics (IFL)
7. RFID identification systems (IFL)
8. Storage and order-picking systems (IFL)
9. Production Management (ifab)
10. Time study (ifab)
11. Accomplishment of workplace design (ifab)

Media
several

Literature
Handout and literature references are available online on ILIAS.

Remarks
none

Course: Productivity Management in Production Systems [2110046]

Coordinators: S. Stowasser
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 28: Lifecycle Engineering (p. 432)[SP_28_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach], SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach]

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

Learning Control / Examinations
Elective Subject: oral exam (approx. 30 min)
Optional Subject: oral exam (approx. 30 min)
The exam is offered in German only!

Conditions

- Compact course (one week full-time)
- Limited number of participants; seats are assigned according the date of registration
- Registration via ILIAS is required
- Compulsory attendance during the whole lecture

Recommendations

- Knowledge of work science is helpful

Learning Outcomes

- Ability to design work operations and processes effecitvely and efficiently
- Instruction in methods of time study (MTM, Data acquisition etc.)
- Instruction in methods and principles of process design
- The Students are able to apply methods for the design of workplaces, work operations and processes.
- The Students are able to apply actual approaches of process and production organisation.

Content

1. Definition and terminology of process design and industrial engineering
2. Tasks of industrial engineering
3. Actual approaches of organisation of production (Holistic production systems, Guided group work et al.)
4. Methods and principles of industrial engineering and production systems
5. Case studies and exercises for process design

Media
Powerpoint, movies, exercises

Literature
Handout and literature is available on ILIAS for download.

Course: Project Management for Engineers [23684]

Coordinators: M. Noe
Part of the modules: SP 59: Innovation and Entrepreneurship (p. 464)[SP_59_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	en

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The students understand and apply safely the basics and tools of project management. The main issues of project communication can be described and applied. The work steps from specification to submission of work are clear and can be applied for different practical situations. The safe application of project changes and claims is a common task. The students can analyse real scenarios in project management and apply the methods learned in this seminar.

Content
This seminar belongs to the key qualifications within the master study and is a non-technical course within the diploma study of electrical engineering and information technology. Each part is structured in a short introduction followed by group exercises. Practical examples are given in this group exercise.

Remarks
The course takes place on 5 afternoons. Current information can be found on the IMS (www.ims.kit.edu) webpage.

Course: Project Workshop: Automotive Engineering [2115817]

Coordinators: F. Gauterin, M. Gießler, M. Frey
Part of the modules: SP 12: Automotive Technology (p. 415)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Winter / Summer Term	de

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
None.

Learning Outcomes
The students are familiar with typical industrial development processes and working style. They are able to apply knowledge gained at the university to a practical task. They are able to analyze and to judge complex relations. They are ready to work self-dependently, to apply different development methods and to work on approaches to solve a problem, to develop practice-oriented products or processes.

Content
During the Project Workshop Automotive Engineering a team of six persons will work on a task given by an German industrial partner using the instruments of project management. The task is relevant for the actual business and the results are intended to be industrialized after the completion of the project workshop.

The team will generate approaches in its own responsibility and will develop solutions for practical application. Coaching will be supplied by both, company and institute.

At the beginning in a start-up meeting goals and structure of the project will be specified. During the project workshop there will be weekly team meetings. Also a milestone meeting will be held together with persons from the industrial company. In a final presentation the project results will be presented to the company management and to institute representatives.

Literature
Steinle, Claus; Bruch, Heike; Lawa, Dieter (Hrsg.), Projektmanagement, Instrument moderner Innovation, FAZ Verlag, Frankfurt a. M., 2001, ISBN 978-3929368277

The scripts will be supplied in the start-up meeting.

Remarks
Selection procedure, applications are to submit in the end of the preceding semester. The admission is limited to 6 persons per team.

Course: Project Mikro Manufacturing: Design and Manufacturing of Micro Systems [2149680]

Coordinators: V. Schulze, B. Matuschka, A. Kacaras
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
None

Recommendations
Knowledge of CAD tools is favorable but not necessary. Previous knowledge of manufacturing is reasonable.

Learning Outcomes
The students . . .

- are able to describe the micro manufacturing processes as well as their characteristics and applications.
- can choose suitable manufacturing processes for a given product.
- are able to describe the process along the CAD-CAM process chain from scratch to manufacturing.
- can explain how the development process for a micro product looks like.
- are able to describe how design for manufacturability works for micro products and where the differences to macroscopic scale are.

Content
The course „Project micro manufacturing: design and manufacturing of a micro system“ combines the basics of micro manufacturing with project work. The project work will be done in cooperation with an industry partner. The students learn the basics of micro milling, micro electric discharge machining, micro laser ablation, micro powder injection molding and micro quality assurance. Furthermore they get to know the CAD-CAM process chain. That is the manufacturing of a production out of a CAD model. The students develop ideas and concepts matching the given task and present the results to the industry partner. Then they create parts that are designed for manufacturability out of their concepts. Those parts are manufactured at the wbk and finally assembled to a prototype. In winter semester 2012/13 innovative couplings for model railways were developed and functional prototypes were built.

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Development of Oil-Hydraulic Powertrain Systems [2113072]

Coordinators: G. Geerling, S. Becker
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach], SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach]

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

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.

Conditions
None.

Recommendations
pre-knowledge in fluid mechanics

Learning Outcomes
The students are able to understand hydraulic systems und to develop them independently. They apply their competences in a simulation of a development project with real hydraulic components within a laboratory tutorial.

Content
The bloc course offered by the Chair of Mobile Machines (Mobima) conveys the basics of planning and development of mobile and industrial hydrostatic systems. The lecturer works for a market leading company producing fluid power drives and controls and gives a deep view into the process of planning and development using real life examples. The contents of the course are:

- marketing, project planning
- hydrostatic circuits
- heat balance, hydraulic accumulators
- filtration, noise lowering
- development exercises + laboratory tutorial

Course: Project Management in Rail Industry [2115995]

Coordinators: P. Gratzfeld
Part of the modules: SP 50: Rail System Technology (p. 456)[SP_50_mach]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
No tools or reference materials may be used during the exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students learn the basic of project management.
They learn about the roles of project manager and project core team.
They understand the project phases and know about processes and tools.
They understand the governance process behind.

Content
Rail vehicles are capital-intensive goods which are manufactured in small series (like aircraft). The work to done at industry and customers is organized in "projects". This is completely different to the way of working in large-scale production (like car industry). Everybody working in this type of business is part of a project and should be aware of the typical processes.
The lecturer provides a comprehensive overview about modern project management for small series of capital-intensive goods.
The content is not only valid for rail vehicles but also other areas.
The following topics will be discussed:
Introduction: definition of project and project management
Project management system: project phases, main processes and supporting processes, governance
Organization: organizational structure within a company, project organization, roles in a project organization
Main processes: project start, project plan, work brake down structure, detailed project schedule, risk and opportunity management, change management, project closure
Governance

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

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

Remarks
The lecture will be held for the last time in the winter term 2019.
Exams can be taken until the end of the examination period of the winter term 2020.

Course: Project management in Global Product Engineering Structures [2145182]

Coordinators: P. Gutzmer

Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 10: Engineering Design (p. 412)[SP_10_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
Auxilary means: none

Conditions
none

Learning Outcomes
Project management is essential for successful companies.
The students are able to describe, explain and compare characteristics and attributes of product development processes based on practical examples of industry.
They are able to specify processes of product development, their necessary organization structures and important attributes.
The participants learn to identify and evaluate aspects of product management within international operating companies.

Content
Product development process
Coordination of product development and handling of complexity
project management
matrix organization
planning / specification / target system
interaction of development and production

Literature
lecture notes

Course: Process Simulation in Forming Operations [2161501]

Coordinators: D. Helm
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach]

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

Learning Control / Examinations
oral examination (30 min)

Conditions
None.

Learning Outcomes
The students can

- describe and classify the most important forming methods
- explain the reasons for the die Ursachen für die gute Umformbarkeit von Metallen in Bezug zu den stattfindenden Phänomenen in der Mikrostruktur erläutern und den Bezug zu den Abläufen in den unterschiedlichen Fertigungsverfahren herstellen
- describe the kinematics of infinitesimal and finite deformations
- explain the differences between different stress tensors in case of finite deformations
- apply simple material models of elasticity and plasticity and explain their operation
- derive the equation of the finite element method based on the balance laws
- describe why the material models are necessary and how they are applied in the whole algorithm
- sketch the process of a FEM-simulation and give the relation to the theoretical basis

Content
Based on basics of continuum mechanics, material theory and numerics the lecture gives an introduction into the simulation of forming operations for metals

- plasticity for metallic materials: dislocations, twinning, phase transformations, aniostropy, hardening
- classification of forming operations and discussion of selected topics
- basics of tensor algebra and tensor analysis
- continuum mechanics: kinematics, finite deformations, balance laws, thermdydnamics
- material theory: basics, modelling concepts, plasticity and visco plasticity, yield functions (von Mises, Hill, ...), kinematic and isotropic hardening, damage
- thermomechanical coupling
- modelling of contact
- finite element method: explicit and implicite formulations, types of elements, numerical integration of material models
- process simulation of selected problems of sheet metal forming

Course: Advanced powder metals [2126749]

Coordinators: R. Oberacker
Part of the modules: SP 43: Technical Ceramics and Powder Materials (p. 449)[SP_43_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

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

Learning Control / Examinations
The assessment consists of an oral exam (20-30 min) taking place at the agreed date. The re-examination is offered upon agreement.

Conditions
None.

Recommendations
Knowledge of basic material science is assumed.

Learning Outcomes
The students know the basics of powder metallurgy. They are able to assess the conditions for applying either powder metallurgy or competing production methods. They have knowledge on production, properties and application of the most important PM materials.

Content
The lecture gives an overview on production, properties and application of structural and functional powder metallurgy material. The following groups of materials are presented: PM High Speed Steels, Cemented Carbides, PM Metal Matrix Composites, PM Specialities, PM Soft Magnetic and Hard Magnetic Materials.

Media
Slides for the lecture:
available under http://ilias.studium.kit.edu

Literature

- W. Schatt ; K.-P. Wieters ; B. Kieback. „Pulvermetallurgie: Technologien und Werkstoffe“, Springer, 2007
- R.M. German. “Powder metallurgy and particulate materials processing. Metal Powder Industries Federation, 2005
- F. Thümmler, R. Oberacker. “Introduction to Powder Metallurgy”, Institute of Materials, 1993

Course: Quality Management [2149667]

Coordinators: G. Lanza
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
The assessment is carried out as a written exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students . . .

- are capable to comment on the content covered by the lecture.
- are capable of substantially quality philosophies.
- are able to apply the QM tools and methods they have learned about in the lecture to new problems from the context of the lecture.
- are able to analyze and evaluate the suitability of the methods, procedures and techniques they have learned about in the lecture for a specic problem.

Content
Based on the quality philosophies Total Quality Management (TQM) and Six Sigma, the lecture deals with the requirements of modern quality management. Within this context, the process concept of a modern enterprise and the process-specic elds of application of quality assurance methods are presented. The lecture covers the current state of the art in preventive and non-preventive quality management methods in addition to manufacturing metrology, statistical methods and service-related quality management. The content is completed with the presentation of certication possibilities and legal quality aspects.
Main topics of the lecture:

- The term “quality”
- Total Quality Management (TQM) and Six Sigma
- Universal methods and tools
- QM during early product stages – product denition
- QM during product development and in procurement
- QM in production – manufacturing metrology
- QM in production – statistical methods
- QM in service
- Quality management systems
- Legal aspects of QM

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Reactor Safety I: Fundamentals [2189465]

Coordinators: V. Sánchez-Espinoza
Part of the modules: SP 21: Nuclear Energy (p. 422)[SP_21_mach]

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

Learning Control / Examinations
oral examination
Duration: approximately 30 minutes

Conditions
Knowledge in energy technology, nuclear power plants, reactor physics, thermal hydraulic of nuclear reactors is welcomed

Learning Outcomes

- Knowledge of fundamentals of nuclear safety (technology, safety concepts, nuclear regulation)
- Gain understanding of safety features and systems of a nuclear power plant
- Ability to understand the interactions of different areas e.g. thermal hydraulics, neutronics, materials, human factors, organisation and management of a nuclear power plant
- Get familiar with safety analysis methodologies for nuclear power plants
- Get insights about accidents and its radiological consequences e.g. Fukushima severe accident

Content
In the lecture, the fundamental principles and concepts of reactor safety explained. They facilitate the assessment of the safety status of nuclear power plants and the interpretation of incidents or accidents as such as Chernobyl or Fukushima. Starting with the explanations of the technical safety features of reactor systems, the safety concepts of different reactor types are discussed. The initiation and progression of incidents/accidents as well as the methods for the safety evaluation are also presented in this lecture. Discussing the Fukushima accident, the radiological risk from nuclear power plants together with the counter measures to stop severe accident and to limit the consequences will be explained. Finally, new development to increase the safety or reactors of Generation III and IV will be presented.
Lecture Content:

- National and international nuclear regulations
- Fundamental principles of reactor safety
- Implementation of safety principles in nuclear power plants of generation 2
- Safety analysis and methods for safety assessment
- Nuclear events and accidents and its evaluation methods
- Discussion severe accidents e.g. the Fukushima accident
- Safety features of reactor systems of generation 3 and 4

Literature

- G. Kessler at al; Risks of Nuclear Energy Technology- Safety Concepts of Light Water Reactors. Springer Verlag 2014.
- B. R. Sehgal; Nuclear Safety in LWR: Severe Accident Phenomenology. Academic Press Elsevier. 2012.
- John C. Lee and Norman J. McCormick.July; Risk and Safety Analysis of Nuclear Systems. 2011
- G. Petrangeli; Nuclear Safety. Elsevier Butterworth-Heinemann. 2006
- J. N. Lillington; Light Water Reactor Safety: The Development of Advanced Models and Codes for Light Water Reactor Safety Analysis. Elsevier 1995.

Course: Computational Dynamics [2162246]

Coordinators: C. Proppe
Part of the modules: (p. 466)[SP_61_mach], SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], (p. 465)[SP_60_mach], SP 30: Applied Mechanics (p. 434)[SP_30_mach]

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

Learning Control / Examinations
Oral examination, no auxiliary means allowed

Conditions
none

Recommendations
none

Learning Outcomes
The lecture teaches the ability to compute solutions for problems in structure dynamics. For this purpose differential equations for the vibration of structure elements are presented and solved by means of numerical methods.

Content
1. Fundamentals of elasto-kinetics (Equations of motion, principle of Hamilton and principle of Hellinger-Reissner)
2. Differential equations for the vibration of structure elements (bars, plates)
3. Numerical solutions of the equations of motion
4. Numerical algorithms
5. Stability analyses

Literature
1. Lecture notes (in German) will be provided!
2. M. Géradin, B. Rixen: Mechanical Vibrations, Wiley, Chichester, 1997

Remarks
The course takes place every two years (in pair years).

Course: Computational Vehicle Dynamics [2162256]

Coordinators: C. Proppe

Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 30: Applied Mechanics (p. 434)[SP_30_mach], SP 50: Rail System Technology (p. 456)[SP_50_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], (p. 466)[SP_61_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
Oral examination, no auxiliary means allowed

Conditions
none

Recommendations
none

Learning Outcomes
This course serves as an introduction to the computational modelling and simulation of the technical system road/vehicle. A method based perspective is taken, which allows for a unified treatment of various kinds of vehicles. The vehicle model is obtained by dividing the system into functional subsystems and defining interfaces between these subsystems. In the first part of the course, vehicle models will be developed based on models of the suspensions, the road, and the contact forces between road and vehicle. The focus of the second part of the course is on computational methods for linear and non-linear models of vehicle systems. The third part of the course discusses design criteria for stability, safety and ride comfort.The multi body dynamics software Simpack will be used.

Content
1. Introduction
2. Models of load bearing systems
3. Contact forces between wheels and roadway
4. Simulation of roadways
5. Vehicle models
6. Methods of calculation
7. Performance indicators

Literature
1. K. Popp, W. Schiehlen: Fahrzeugdynamik, B. G. Teubner, Stuttgart, 1993
2. H.-P. Willumeit: Modelle und Modellierungsverfahren in der Fahrzeugdynamik, B. G. Teubner, Stuttgart, 1998
3. H. B. Pacejka: Tyre and Vehicle Dynamics. Butterworth Heinemann, Oxford, 2002
4. K. Knothe, S. Stichel: Schienenfahrzeugdynamik, Springer, Berlin, 2003

Remarks
The course takes place every two years (impair years only).

Course: Computerized Multibody Dynamics [2162216]

Coordinators: W. Seemann
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], (p. 466)[SP_61_mach], SP 40: Robotics (p. 445)[SP_40_mach]

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

Learning Control / Examinations
Oral exam

Conditions
None.

Recommendations
Knowledge of EM III, EM IV

Learning Outcomes
Goal of the course is to demonstrate the students that many tasks which are necessary to derive the equations of motion can be done by computers and corresponding software. This enables the user to focus both on mechanics and on modelling. This includes both kinematics as well as dynamcis and different methods to derive the equations of motion. The numerical integration is known and the students realize that the result of the simulation does not only depend on the physical model but also on the type of integration scheme and the corresponding parameters. Application of software without detailed knowledge of the principles which are behind this software is therefore dangerous.

Content
Description of the orientation of a rigid body, angular velocity, angular acceleration, derivatives in different referrence frames, derivatives of vectors, holonomic and nonholonomic constraints, derivation of the equations of motion using d'Alembert's principle, the principle of virtual power, Lagrange's equations or Kane's equations. Structure of the equations of motion, foundations of numerical integration.

Media
Following Programs are used: AUTOLEV, MATLAB, MATHEMATICA/MAPLE

Literature
Kane, T.: Dynamics, Theory and Applications, McGrawHill, 1985
AUTOLEV: User Manual

Course: Computational Mechanics I [2161250]

Coordinators: T. Böhlke, T. Langhoff
Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 30: Applied Mechanics (p. 434)[SP_30_mach]

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

Learning Control / Examinations
oral examination
Prerequisites by attestations during associated tutorials

Conditions
None.

Recommendations
Lectures “Mathematical Methods in Strength of Materials” and “Introduction to the Finite Element Method”
This course is geared to MSc students.

Learning Outcomes
The students can

- analyse and evaluate different methods for solving linear systems of equations
- list and assess basics and assumptions of the linear elasticity
- list methods for solving the boundary value problem of linear elasticity
- apply and evaluate the matrix displacement method
- list and analyse variational principles of linear elasticity
- analyse the different aspects and steps of the finite-element-method
- solve worksheet problems to topics of the lecture by writing own MATLAB code

Content

- numerical solution of linear systems
- basics of boundary value problems of linear elasticity
- solution methods of boundary value problem of linear elasticity;
- matrix displacement method
- variational principles of linear elasticity
- finite-element-technology for linear static problems

Literature
Simó, J.C.; Hughes, T.J.R.: Computational Inelasticity. Springer 1998.
Haupt, P.: Continuum Mechanics and Theory of Materials. Springer 2002.
Belytschko, T.; Liu,W.K.; Moran, B.: Nonlinear FE for Continua and Structures. JWS 2000.
W. S. Slaughter: The linearized theory of elasticity. Birkhäuser, 2002.
J. Betten: Finite Elemente für Ingenieure 2, Springer, 2004.

Course: Computational Mechanics II [2162296]

Coordinators: T. Böhlke, T. Langhoff
Part of the modules: SP 06: Computational Mechanics (p. 411)[SP_06_mach], SP 30: Applied Mechanics (p. 434)[SP_30_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	de

Learning Control / Examinations
oral examination

Conditions
Successful participation in lecture “Computational Mechanics I”

Recommendations
This course is geared to MSc students.

Learning Outcomes
The students can

- apply and evaluate algorithms for solving a non-linear equation of systems of equations
- compute stresses and strains in the framework of linear elasticity and of infinitesimal plasticity
- apply and assess models of generalized standard materials
- list the basic equations of linear thermo-elasticity
- develop user-subroutines within FORTRAN for use within commercial FE-Codes
- perform a finite-element-analysis with ABAQUS for elastic-plastic materials using or developing user-subroutines

Content

- overview quasistatic nonlinear phenomena
- numerics of nonlinear systems
- foundations of nonlinear continuum mechanics
- balance equations of geometrically nonlinear solid mechanics
- finite elasticity
- infinitesimal plasicity
- linear and gemetrically nonlinear thermoelasticity

Literature
Simó, J.C.; Hughes, T.J.R.: Computational Inelasticity. Springer 1998.Haupt, P.: Continuum Mechanics and Theory of Materials. Springer 2002.Belytschko, T.; Liu,W.K.; Moran, B.: Nonlinear FE for Continua and Structures. JWS 2000.

Course: Reduction methods for the modeling and the simulation of combustion processes [2166543]

Coordinators: V. Bykov, U. Maas
Part of the modules: SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

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

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
None

Learning Outcomes
After completing this course students will be able to:

- explain the fundamental mathematical concepts in model reduction for reacting flows,
- perform an analysis of kinetic models of reacting flows,
- analyse ideal and reduced models used to describe different combustion regimes,
- understand and asses the predominant methods for the mathematical analysis of reduced models.

Content
The course will introduce the principles of model reduction of chemical kinetic models of combustion processes. The basic mathematical concepts and methods of analysis of chemical reaction mechanisms will be outlined in the context of model reduction. The detailed implementation scheme of model reduction will be introduced. The course will cover simplified and idealized models of combustion (e.g. auto-ignition, explosion, deflagration etc.), which will be analyzed and reduced. The main analytical methods and numerical tools will be presented, evaluated and illustrated by using these simple examples.

Literature
N. Peters, B. Rogg: Reduced kinetic mechanisms for aplication in combustion systems, Lecture notes in physics, 15, Springer Verlag, 1993.

Course: Reliability Engineering 1 [2169550]

Coordinators: A. Konnov
Part of the modules: SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	en

Learning Control / Examinations
written, 90 min
no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Basic knowledge in formal logic, KV-maps, probability calculus.
In combination with lesson 2170490 Combined Cycle Power Plants.

Learning Outcomes

Content
Technical background: instrumentation and control systems in power plants
Introduction to reliability theory
Introduction to probability theory
Introduction to formal logic
Introduction to statistic

Literature
Lesson script (link will be available)
Recommended books
1. Birolini, Alessandro *Reliability Engineering Theory and Practice*
2. Pham, Hoang *Handbook of reliability engineering*

Course: Renewable Energy – Resources, Technology and Economics [2581012]

Coordinators: R. McKenna
Part of the modules: SP 59: Innovation and Entrepreneurship (p. 464)[SP_59_mach]

ECTS Credits	Hours per week	Term	Instruction language
3,5	2/0	Winter term	en

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

Conditions
None.

Learning Outcomes
The student:

- understands the motivation and the global context of renewable energy resources.
- gains detailed knowledge about the different renewable resources and technologies as well as their potentials.
- understands the systemic context and interactions resulting from the increased share of renewable power generation.
- understands the important economic aspects of renewable energies, including electricity generation costs, political promotion and marketing of renewable electricity.
- is able to characterize and where required calculate these technologies.

Content
1. General introduction: Motivation, Global situation
2. Basics of renewable energies: Energy balance of the earth, potential definition
3. Hydro
4. Wind
5. Solar
6. Biomass
7. Geothermal
8. Other renewable energies
9. Promotion of renewable energies
10. Interactions in systemic context
11. Excursion to the "Energieberg" in Mühlburg

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

Literature
Elective literature:

- Kaltschmitt, M., 2006, Erneuerbare Energien : Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, aktualisierte, korrigierte und ergänzte Auflage Berlin, Heidelberg : Springer-Verlag Berlin Heidelberg.
- Kaltschmitt, M., Streicher, W., Wiese, A. (eds.), 2007, Renewable Energy: Technology, Economics and Environment, Springer, Heidelberg.
- Quaschning, V., 2010, Erneuerbare Energien und Klimaschutz : Hintergründe - Techniken - Anlagenplanung – Wirtschaftlichkeit München : Hanser, Ill.2., aktualis. Aufl.
- Harvey, D., 2010, Energy and the New Reality 2: Carbon-Free Energy Supply, Eathscan, London/Washington.
- Boyle, G. (ed.), 2004, Renewable Energy: Power for a Sustainable Future, 2nd Edition, Open University Press, Oxford.

Course: Robotics I – Introduction to robotics [24152]

Coordinators: R. Dillmann, T. Asfour
Part of the modules: SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	2	Winter term	de

Learning Control / Examinations

Conditions
None.

Recommendations
It is recommended to visit LV "Robotik II" and LV „Robotik III" in conjunction with „Robotik I".

Learning Outcomes

Content

Media
Slides

Literature
Elective literature:
Fu, Gonzalez,Lee: Robotics - Control, Sensing, Vision, and Intelligence
Russel, Norvig: Artificial Intelligenz - A Modern Approach, 2nd. Ed.

Course: Robotik II: Humanoide Robotic [24644]

Coordinators: R. Dillmann, T. Asfour
Part of the modules: SP 40: Robotics (p. 445)[SP_40_mach], SP 32: Medical Technology (p. 437)[SP_32_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	de

Learning Control / Examinations
The assessment is explained in the module description.

Conditions
None.

Recommendations
A prior attendance of the lecture „Robotik I“ is recommended, but not mandatory.

Learning Outcomes
The student understands the main principles and differences concerning methods for programming industrial robots on the one hand and autonomous service robots on the other hand. The student is able to present and describe applicable programming concepts for realistic robotic application scenarios

Content
Complementary to the lectures „Robotik I“ and „Robotik III“, the task modeling and execution aspects of industrial production and service robotics are presented more closely. Different methods like manual, textual and graphic programming of robots as well as the necessary tools are discussed. Furthermore, the internal modeling of environment and task knowledge in the robot as well as suitable planning methods are presented. Finally, learning and planning approaches for (semi-)autonomous service robots are discussed with a focus on dynamic, real world settings and the latest state of the art.

Media
Slides, videos, exercises, practical demonstration in the laboratory

Course: Robotik III - Sensors in Robotics [24635]

Coordinators: R. Dillmann, Meißner, Gonzalez, Aguirre
Part of the modules: SP 40: Robotics (p. 445)[SP_40_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 32: Medical Technology (p. 437)[SP_32_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	de

Learning Control / Examinations
The assessment is explained in the module description.

Conditions
None.

Recommendations
Previous attendance of the lecture „Robotik I" is helpful, but not mandatory.

Learning Outcomes
The student has to understand the principles of sensors that are essential and common in robotics. The student has to understand the data flow, starting from the physical measurement, over digitization, application of the sensor model to image processing, feature extraction and the integration of the information in an environment model. The student has to be able to propose suitable sensor concepts for simple tasks and to justify them.

Content
The lecture Robotics III complements the lecture Robotics I with a broad overview over sensors used in robotics and the interpretation of their data. One focus of the lecture is on the topic of computer vision, which is being dealt with from data aquisition, over calibration to object recognition and localization.
Sensors are important subcomponents of control circuits and enable robots to perform their tasks safely. Furthermore sensors serve to capture the environment as well as dynamical processes and actions in the surroundings of the robots. The topics that are addressed in the lecture, are as follows: Sensor technology for a whole taxonomy of sensor systems (including image and 3D sensors), sensor modeling (including color calibration and hdr imaging), theory and practice of digital signal processing, machine vision, multi-sensor integration and fusion.
Among others, sensor systems such as relative position sensors (optical encoders, potentiometer), velocity sensors (encoder, tachometer), acceleration sensors (piezo-resistive, piezo-electric, optical and others), inertial sensors (gyroscope, gravitometer and others), tactile sensors (foil sensors, pressure sensitive materials and others), proximity sensors, distance sensors (ultrasonic, laser, time-of-flight, interferometry, structured light, stereo camera systems and others), image sensors (photodiode, CCD and others), absolute position sensors (GPS, fiducial markers). Laser sensors as well as image sensors are dealt with priority.

Media
Slides, script.

Course: Medical Robotics [24681]

Coordinators: J. Raczkowsky, Raczkowsky
Part of the modules: SP 32: Medical Technology (p. 437)[SP_32_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	de

Learning Control / Examinations
The assessment is explained in the module description.

Conditions
None.

Learning Outcomes
The student should understand the specific demands of surgical treatments on automation using robot. Additionally he/she should become acquainted with basic methods of registration of image data and how to use them. This includes also also physical registration. Generally, the course should enable the student to design a work flow for a robot assisted treatment.

Content
In the motivation, varies scenario of robot assisted usage in surgical environment will be described and by examples categorized. The basics of robotics will be entertained by the classic kinematic configurations. The characteristic indicators like degree of freedom, kinematic chain, work space and work load will be introduced. Then, the different modules of the robot assisted surgical work flow will be figured out. This starts with the description of all relevant tomographical modalities. They will be explicated by their physical basics and their measurement evidence for anatomical and pathological information. Data formats and communication play an important role in this context. This will be followed by medical image processing with the focus on segmentation. The next step ist the geometrical 3D reconstruction of anatomical structures. This lead to an attributed patient model using the processed data of different tomographical modalities. This will be completed by different approaches for the modelling of tissue parameters. The usage of the attributed patient model for reasons of visualisation and operation planning is the next issue. The differing concepts of planning by medical doctors and engineers will be shown in this frame. Beside geometrical planning the role of work flow planning will be worked out. This becomes a more and more important topic in clinical routine. Simulation could be seen as a verification instrument of operation planning. Sub topics in this context is functional anatomical simulation, robot simulation with positioning verification and training systems. The intraoperative part of the robot aided work flow comprises physical registration, navigation, augmented reality and surgical robot systems. They will exemplified by basic principles and examples of applications. Important topics in this frame are techniques of tissue cutting and approaches for micro and nano surgery. The lecture closes with a short discourse on specific safety matters and legal aspects of medical products.

Media
PowerPoint-slides online

Literature
Elective literature:
- Springer Handbook of Robotics, Siciliano, Bruno; Khatib, Oussama (Eds.) 2008, LX, 1611 p. 1375 illus., 422 in color. With DVD., Hardcover, ISBN:978-3-540-23957-4
- Heinz Wörn, Uwe Brinkschulte "Echtzeitsysteme", Springer, 2005, ISBN: 3-540-20588-8
- Proccedings of Medical image computing and computer-assisted intervention (MICCAI ab 2005)
- Proccedings of Computer assisted radiologiy and surgery (CARS ab 2005)
- Tagungsbände Bildverarbeitung für die Medizin (BVM ab 2005)

Course: Failure Analysis [2182572]

Coordinators: C. Greiner, J. Schneider
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 47: Tribology (p. 453)[SP_47_mach]

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

Learning Control / Examinations
oral

Duration: ca. 30 minutes

no notes

Conditions
None.

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

Learning Outcomes
The students are able to discuss damage evaluation and to perform damage investigations. They know the common necessary investigation
methods and can regard failures considering load and material resistance. Furthermore they can describe and discuss the most important types of failure and damage appearance.

Content
Aim, procedure and content of examining failure

Examination methods

Types of failure:
Failure due to mechanical loads
Failure due to corrosion in electrolytes
Failure due to thermal loads
Failure due to tribological loads

Damage systematics

Literature

1. G. Lange: Systematische Beurteilung technischer Schadensfälle, 6. Auflage, WILEY-VCH Verlag, 2014, ISBN 978-3-527-68316-1, In der KIT-BIB online verfügbar!

2. A. Neidel, et al.: Handbuch Metallschäden – REM-Atlas und Fallbeispiele zur Ursachenanalyse und Vermeidung, 2. Auflage, Hanser Verlag, 2011, ISBN 978-3-446-42966-6

3. J. Grosch, et al.: Schadenskunde im Maschinenbau: Charakteristische Schadensursachen – Analyse und Aussagen von Schadensfällen, 6. Auflage, Expert-Verlag, 2014, ISBN 978-3-816-93172-0

4. E. Wendler-Kalsch, H. Gräfen: Korrosionsschadenkunde, Springer-Verlag, 1998, ISBN 3-540-63377-4

Course: Rail Vehicle Technology [2115996]

Coordinators: P. Gratzfeld
Part of the modules: SP 50: Rail System Technology (p. 456)[SP_50_mach]

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

Learning Control / Examinations
Oral examination
Duration: 20 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes
The students are familiar with concept and structure of modern rail vehicles.
They learn about advantages and disadvantages of different types of traction drives and judge which one fits best for each application.
They understand brakes from a vehicular and an operational point of view. They assess the fitness of different brake systems.
They know about the basics of running dynamics and bogies.
They define suitable vehicle concepts based on requirements for modern rail vehicles.

Content
System structure of rail vehicles: tasks and classification of rail vehicles, main systems, vehicle system technology
Drives: Electric and non-electric traction drives
Brakes: Tasks, basics, principles, brake control
Bogies: forces, running gears, axle configuration
Vehicle concepts: trams, metros, regional trains, double deck coaches, locomotives
Examples of existing rail vehicles were discussed.

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

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

Remarks
None.

Course: Welding Technology [2173571]

Coordinators: M. Farajian
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 39: Production Technology (p. 443)[SP_39_mach]

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

Learning Control / Examinations
Oral exam, about 20 minutes

Conditions
None.

Recommendations
Basics of material science (iron- and non-iron alloys), materials, processes and production, design.
All the relevant books of the German Welding Institute (DVS: Deutscher Verband für Schweißen und verwandte Verfahren) in the field of welding and joining is recommended.

Learning Outcomes
The students have knowledge and understanding of the most important welding processes and its industrial application.
They are able to recognize, understand and handle problems occurring during the application of different welding processes relating to design, material and production.
They know the classification and the importance of welding technology within the scope of connecting processes (advantages/disadvantages, alternatives).
The students will understand the influence of weld quality on the performance and behavior of welded joints under static and cyclic load.
How the fatigue life of welded joints could be increased, will be part of the course.

Content
definition, application and differentiation: welding,
welding processes, alternative connecting technologies.
history of welding technology
sources of energy for welding processes
Survey: Fusion welding,
pressure welding.
weld seam preparation/design
welding positions
weldability
gas welding, thermal cutting, manual metal-arc welding
submerged arc welding
gas-shielded metal-arc welding, friction stir welding, laser beam and electron beam welding, other fusion and pressure welding processes
static and cyclic behavior of welded joints,
fatigue life improvement techniques

Literature
Vorlesungsmaterial zum Thema Fügetechnik von Herrn
Professor Dr. -Ing. Helmut Wohlfahrt
Für ergänzende, vertiefende Studien gibt das
Handbuch der Schweißtechnik von J. Ruge, Springer Verlag Berlin, mit seinen vier Bänden
Band I: Werkstoffe
Band II: Verfahren und Fertigung
Band III: Konstruktive Gestaltung der Bauteile
Band IV: Berechnung der Verbindungen
einen umfassenden Überblick. Der Stoff der Vorlesung Schweißtechnik findet sich in den Bänden I und II. Einen kompakten Einblick in die Lichtbogenschweißverfahren bietet das Bändchen

H. Nies: Lichtbogenschweißtechnik, Bibliothek der Technik Band 57, Verlag moderne Industrie AG und Co., Landsberg / Lech

Im Übrigen sei auf die zahlreichen Fachbücher des DVS Verlages, Düsseldorf, zu allen Einzelgebieten der Fügetechnik verwiesen.

Course: Fatigue of Metallic Materials [2173585]

Coordinators: K. Lang
Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach]

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

Learning Control / Examinations
Oral exam, about 20 minutes

Conditions
none

Recommendations
Basic knowledge in Material Science will be helpful

Learning Outcomes
The students are able to recognise the deformation and the failure behaviour of metallic materials under cyclic loading and to assign it to the basic microstructural processes. They know the sequence and the development of fatigue damages and can evaluate the initiation and the growth of fatigue cracks.
The students can assess the cyclic strength behaviour of metallic materials and components both qualitatively and quantitatively and know the procedures for the assessment of single-stage, multistage and stochastic cyclical loadings. Furthermore, they can take into account the influence of residual stresses.

Content
Introduction: some interesting cases of damage
Cyclic Stress Strain Behaviour
Crack Initiation
Crack Propagation
Lifetime Behaviour under Cyclic Loading
Fatigue of Notched Components
Influence of Residual Stresses
Structural Durability

Literature
Lecture notes that include a list of current literature will be distributed.

Course: Schwingungstechnisches Praktikum [2161241]

Coordinators: A. Fidlin
Part of the modules: (p. 465)[SP_60_mach]

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

Learning Control / Examinations
Colloquium to each session.

Conditions
The courses [2161241] and [2162225] can not be combined.

Recommendations
Vibration theory, mathematical methods of vibration theory, dynamic stability, nonlinear vibrations

Learning Outcomes
* Introduction to common measurement principles for mechanical vibrations
* selected vibrational problems are demonstrated from a theoretical and experimental aspect
* Measurement, evaluation and
comparison with analytical calculations.

Content
* Frequency response of a force-excited oscillator (1DoF)
* stochastically excited oscillator (1DoF)
* digital processing of measurement data
* forces vibrations of a Duffing oscillator
* isolation of acoustical waves by means of additional masses
* critical speeds of a rotor in elastic bearings
* stability of a parametrically excited oscillator
* experimental modal analysis
* friction induced vibrations

Literature
comprehensive instructions will be handed out

Course: Seminar Data Mining in Production [2151643]

Coordinators: G. Lanza
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter / Summer Term	

Learning Control / Examinations
alternative test achievement (graded):

- written elaboration
- oral exam (approx. 30 min)

Conditions
none

Learning Outcomes
The students . . .

- can name, describe and distinguish between different methods, procedures and techniques of production data analysis.
- can perform basic data analyses with the data mining tool KNIME.
- can analyze and evaluate the results of data analyses in the production environment.
- are able to derive suitable recommendations for action.
- are able to explain and apply the CRISP-DM model.

Content
In the age of Industry 4.0, large amounts of production data are generated by the global production networks and value chains. Their analysis enables valuable conclusions about production and lead to an increasing process efficiency. The aim of the seminar is to get to know production data analysis as an important component of future industrial projects. The students get to know the data mining tool KNIME and use it for analyses. A specific industrial use case with real production data enables practical work and offers direct references to industrial applications. The participants learn selected methods of data mining and apply them to the production data. The work within the seminar takes place in small groups on the computer. Subsequently, presentations on specific data mining methods have to be prepared.

Media
KNIME Analytics Platform

Remarks
The number of students is limited to twelve. Dates and deadlines for the seminar will be announced at https://www.wbk.kit.edu/studium-und-lehre.php.

Course: Seminar for Rail System Technology [2115009]

Coordinators: P. Gratzfeld
Part of the modules: SP 50: Rail System Technology (p. 456)[SP_50_mach]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Winter / Summer Term	de

Learning Control / Examinations
Examination: Writing a Seminararbeit, final presentation

Conditions
None.

Learning Outcomes

- The students become aware of the fundamental relations and interdependencies between rail vehicles, infrastructure and operation in a rail system.
- They are able to explain the railway history along general lines, to analyse the status quo and future developments of the railway and mobility sector.
- They overview the technical components of a rail system (in particular rail vehicle engineering).
- The students be aware of the characteristics of a project and the meaning of project management. They are able to transfer their project knowledge to the task of creating a scientific paper.
- They are able to specify the essential requirements on scientific papers, to do a literature research and to use software to manage literature.

Content

- Railway system: railway as system, subsystems and interdependencies, definitions, laws, rules, railway and environment, economic impact, history, challenges and future developments in the context of mega trends
- Operation: Transportation, public/regional/long-distance transport, freight service, scheduling
- System structure of railway vehicles: Tasks and classification, main systems
- Project management: definitions, project management, main and side processes, transfer to practice
- Scientific working: structuring and writing of scientific papers, literature research, scheduling (mile stones), self-management, presentation skills, using the software Citavi for literature and knowledge management, working with templates in Word, giving and taking feedback
- The learnt knowledge regarding scientific writing is used to elaborate a Seminararbeit. To this the students create a presentation, train and reflect it and finally present it to an auditorium.

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

Remarks
max. 10 participants

Course: Seminar for Automobile and Traffic History [5012053]

Coordinators: T. Meyer
Part of the modules: SP 12: Automotive Technology (p. 415)[SP_12_mach]

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

Learning Control / Examinations
oral (thesis paper and presentation)

Conditions
None.

Learning Outcomes
The students acquired basic knowledge and an overview about automobile and traffic history with changing focus every semester.

Content
Seminar focus changes every semester, details see public announcement.

Literature
Seminar focus changes every semester, details see public announcement.

Course: Safety Engineering [2117061]

Coordinators: H. Kany

Part of the modules: SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach], SP 10: Engineering Design (p. 412)[SP_10_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 28: Lifecycle Engineering (p. 432)[SP_28_mach], SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach]

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

Learning Control / Examinations
oral / written (if necessary)

Conditions
none

Recommendations
none

Learning Outcomes
Students are able to:

- Name and describe relevant safety conceps of safety engeneering,
- Discuss basics of health at work and labour protection in Germany,
- Evaluate the basics for the safe methods of design of machinery with the national and european safety regulations and
- Realize these objectives by using examples in the field of storage and material handling systems.

Content
The course provides basic knowledge of safety engineering. In particular the basics of health at the working place, job safety in Germany, national and European safety rules and the basics of safe machine design are covered. The implementation of these aspects will be illustrated by examples of material handling and storage technology. This course focuses on: basics of safety at work, safety regulations, basic safety principles of machine design, protection devices, system security with risk analysis, electronics in safety engineering, safety engineering for storage and material handling technique, electrical dangers and ergonomics. So, mainly, the technical measures of risk reduction in specific technical circumstances are covered.

Media
presentations

Literature
Defren/Wickert: Sicherheit für den Maschinen- und Anlagenbau, Druckerei und
Verlag: H. von Ameln, Ratingen, ISBN: 3-926069-06-6

Remarks
none

Course: Signals and Systems [23109]

Coordinators: F. Puente, F. Puente León
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 31: Mechatronics (p. 435)[SP_31_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	2	Winter term	de

Learning Control / Examinations
The assessment consists of a written exam (approx. 120 minutes) according to sec. 4 subsec. 2 no. 1 study and examination regulations.
The grade of the course corresponds to the grade of the written exam.

Conditions
none

Learning Outcomes

Content

Media
Slides
work sheets

Literature
Prof. Dr.-Ing. Kiencke: Signale und Systeme; Oldenbourg Verlag, 2008
Elective literature:
Will be announced in the lecture.

Course: Simulation of the process chain of continuously fiber reinforced composite structures [2114107]

Coordinators: L. Kärger
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 30: Applied Mechanics (p. 434)[SP_30_mach]

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

Learning Control / Examinations
oral 20 - 30 minutes
auxiliary means: none

Conditions
technical mechanics

Learning Outcomes
The students understand that the microstructure of fibre reinforces plastics (FRP) and the resulting material behavior is mainly influenced by the manufacturing process. They know the simulation steps needed to virtually describe the process chain of RTM (resin transfer molding) parts. They are able to explain the principal mechanical processes of draping, molding and curing and can name their influences on the structural behavior.

Content
Virtual Process Chain
Draping simulation:
draping behavior of textiles
draping process, kinematic draping simulation, FE draping simulation
Molding simulation:
Principles of fluid mechanics, viscosity and permeability, molding simulation within the CAE chain
Curing simulation and distortion:
process of crosslinking, resin kinetics, thermomechanics, internal stresses, part distortion
Structural simulation:
Modelling of multilayer laminate,
influence of manufacturing effects

Literature
H. Altenbach, J. Altenbach, W. Kissing; Mechanics of Composite Structural Elements . ISBN 978-3-642-07411-0 Springer-Verlag Berlin Heidelberg, 2004.
E. J. Barbero: Introduction to Composite Materials Design. CRC Press, Boca Raton, FL, 2. edition, 2011.
Bickerton, S.; Sozer, E.M. Simacek, P. and Advani, S.G.: "Fabric structure and mold curvature effects on preform permeability and mold filling in the RTM process. Part II. Predictions and comparisons with experiments". Composites Part A 31: 439–458, 2000.
Kärger, L.; Bernath, A.; Fritz, F.; Galkin, S.; Magagnato, D.; Oeckerath, A.; Schön, A.; Henning, F.: Development and validation of a CAE chain for unidirectional fibre reinforced composite components. Composite Structures 132: 350–358, 2015.
Stephen W. Tsai and J. Daniel D. Melo: Composite Materials Design and Testing. Composites Design Group, 978-0-9860845-1-5 Stanford University , 2015.

Course: Simulation of Coupled Systems [2114095]

Coordinators: M. Geimer
Part of the modules: SP 34: Mobile Machines (p. 441)[SP_34_mach], (p. 466)[SP_61_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	4	Summer term	de

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place in every semester. Re-examinations are offered at every ordinary examination date.
Required for the participation in the examination is the preparation of a report during the semester.

Conditions
None.

Recommendations
It is recommended to have:

- Knowledge of Creo (ideally in current version)
- Basic knowledge of Matlab/Simulink
- Basic knowledge of dynamics of machines
- Basic knowledge of hydraulics

Learning Outcomes
After completion of the course, students are able to:

- build a coupled simulation
- parameterize models
- perform simulations
- conduct troubleshooting
- check results for plausibility

Content

- Basics of multi-body and hydraulic simulation programs
- Possibilities of coupled simulations
- Modelling and Simulation of Mobile Machines using a wheel loader
- Documentation of the result in a short report

Literature
Elective literature:

- Software guide books (PDFs)
- Information about wheel-type loader specifications

Remarks
The number of participants is limited. A registration is mandatory, the details will be announced on the webpages of the *Institute of Vehicle System Technology / Institute of Mobile Machines*. In case of too many applications, attendance will be granted based on pre-qualification.

Course: Simulation in product development process [2185264]

Coordinators: T. Böhlke
Part of the modules: SP 12: Automotive Technology (p. 415)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
This cours is no longer offered.

- written part: 10 pages per person
- presentation: 15 minutes per group

Conditions
Compulsory preconditions: none

Recommendations
None.

Learning Outcomes
The students learn the connections between simulation methods, the necessary IT technique and the integration of such methods within the product development process. They know the basic approximation methods in mechanics and methods of modelling material behaviour using the finite-element-method. The students learn the integration within the product development process as well as the necessity of coupling different methods and systems. They master the modelling of heterogeneous technical systems and know the foundations of virtual reality.

Content

- approximation methods of mechanics: FDM, BEM, FEM, MBS
- material modelling using the finite-element-methode
- product life cycle
- coupling of methods and system integration
- modelling heterogeneous technical systems
- functional Digital Mock-Up (DMU), virtual prototypes

Literature
sildes of lectures will be available

Course: Simulation of Optical Systems [2105018]

Coordinators: I. Sieber
Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 31: Mechatronics (p. 435)[SP_31_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral examination, 30 minutes

Conditions
none

Learning Outcomes
The students. . .

- know the basics of optical modeling and simulation.
- know the basics of modeling and simulation by means of the Finite-Element Method.
- know the basics of the optical and mechanical design process.
- are able to understand the specifications of optical systems and can use them in optical modeling.
- are able to use design rules.
- are able to conduct basic tolerance analysis.
- are able to assess the need of an inter-domain simulation.

Content
This lecture gives an introduction into optical system's design. The focus is on the system concept: design for manufacture, reliability in operation, as well as interactions between optical and non-optical system components are considered. Practical aspects of optical systems design like e.g. the consideration of design rules to ensure manufacturability, tolerancing of the optical system to ensure a reliable operation, and the coupling of optical and mechanical simulation tools will also be presented. Application of the acquired techniques will be deepened with the help of three case studies.
Contents are as follows:

- Introduction
- Modeling, simulation, and systems design
- Basics of optics
- Properties of optical materials
- Optical imaging
- Ray tracing
- The optical design process
- Basics of the Finite-Element Method (FEM)
- The FEM design process
- Coupling of simulation tools
- Microoptical sub-systems

Literature

- Averill M. Law, W. David Kelton, „Simulation, Modeling & Analysis“, McGraw-Hill, New York (1991)
- R.E. Fischer, „Optical System Design“, SPIE Press, New York (2008)
- G. Pahl, W. Beitz, „Engineering Design“, Springer, Heidelberg (1995Optik, E. Hecht (Oldenbourg, 2005)
- Optical System Design, R. E. Fischer, B. Tadic-Galeb, P. R. Yoder (Mc Graw Hill, 2008)
- Practical Computer-Aided Lens Design, G. H. Smith (Willman-Bell, 1998)
- M. Mayr, U. Thalhofer, „Numerische Lösungsverfahren in der Praxis“, Hanser Verlag München (1993)
- M. Weck, C. Brecher, „Werkzeugmaschinen – Konstruktion und Berechnung“, Springer Heidelberg (2006)

Course: Simulator Exercises Combined Cycle Power Plants [2170491]

Coordinators: T. Schulenberg
Part of the modules: SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	2	Summer term	en

Learning Control / Examinations
Oral examination (ca. 15 min)

Conditions
None.

Recommendations
Participation at the lecture Combined Cycle Power Plants (2170490) is recommended.

Learning Outcomes
The training objective of the course is the qualification for a research-related professional activity in power plant engineering. On the basis of the learned fundamentals in thermodynamics, in instrumentation and control engineering, as well as on the basis of the acquired knowledge of design of combined cycle plants, the participants can operate a real combined cycle power plant. This application creates a deeper understanding of the dynamic processes of the power plant, the specific importance of the plant components and the limits of the load capacity of the components. Participants can optimize normal operation and analyze incidents. They can work self-organized and reflexive. They have communicative and organizational skills in teamwork, even under major technical challenges.

Content
Start-up of the power plant from scratch; load changes and shut down; dynamic response of the power plant in case of malfuctions and of sudden load changes; manual operation of selected components.

Media
The power plant simulator is based on the control system of a real SIEMENS power plant. The English user surface is based on US standard.

Literature
Slides and other documents of the lecture Combined Cycle Power Plants.

Course: Scaling in fluid dynamics [2154044]

Coordinators: L. Bühler
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
Oral
Duration: 30 minutes
no auxiliary means

Conditions
none

Learning Outcomes
The student can extract non-dimensional number from the characteristic properties of flows. From the insights on scaling laws, the students are qualified to identify the influencing quantities from generic experiments and transfer these to real applications. The students can simplify the governing equations of fluid mechanic appropriately and can interpret the achieved results as a basis for efficient solution strategies.

Content

- Introduction
- Similarity rules (examples)
- Dimensional analysis (Pi-theorem)
- Scaling in differential equations
- Scaling in boundary layers
- Self-similar solutions
- Scaling in turbulent shear layers
- Rotating flows
- Magnetohydrodynamic flows

Literature
G. I. Barenblatt, 1979, Similarity, Self-Similarity, and Intermediate Asymptotics, Plenum Publishing Corporation (Consultants Bureau)
J. Zierep, 1982, Ähnlichkeitsgesetze und Modellregeln der Strömungsmechanik, Braun
G. I. Barenblatt, 1994, Scaling Phenomena in Fluid Mechanics, Cambridge University Press

Course: Solar Thermal Energy Systems [2189400]

Coordinators: R. Dagan
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The students
get familiar with the global energy demand and the role of renewable energies
learn about improved designs for using efficiently the potential of solar energy
gain basic understanding of the main thermal hydraulic phenomena which support the work on future innovative applications
will be able to evaluate quantitatively various aspects of the thermal solar systems

Content
I. Introduction to solar energy: Energy resources, consumption and costs
II. The sun as an energy resource:
Structure of the sun, Black body radiation, solar constant, solar spectral distribution
Sun-Earth geometrical relationship
III. Passive and active solar thermal applications.
IV. Fundamentals of thermodynamics and heat transfer
V. Solar thermal systems - solar collector-types, concentrating collectors, solar towers. Heat losses and efficiency
VII. Energy storage
The course deals with fundamental aspects of solar energy. Starting from a global energy panorama the course deals with the sun as a thermal energy source. In this context, basic issues such as the sun's structure, blackbody radiation and solar–earth geometrical relationship are discussed. In the next part, the lectures cover passive and active thermal applications and review various solar collector types including concentrating collectors and solar towers and the concept of solar tracking. Further, the collector design parameters determination is elaborated, leading to improved efficiency. This topic is augmented by a review of the main laws of thermodynamics and relevant heat transfer mechanisms.
The course ends with an overview on energy storage concepts which enhance practically the benefits of solar thermal energy systems.

Literature
Foster, Ghassemi, cota,; Solar Energy
Duffie and Beckman; Solar engineering of thermal processes
Holman:, Heat transfer
Heinzel; script to solar thermal energy (in German)

Course: Theory of Stability [2163113]

Coordinators: A. Fidlin
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach], (p. 465)[SP_60_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Summer term	de

Learning Control / Examinations
Oral examination

Conditions
None.

Recommendations
Vibration theory, mathematical methods of vibration theory

Learning Outcomes

- to learn the most important methods of the stability analysis
- to apply the stabiliy analysis for equilibria
- to apply the stabiliy analysis for periodic solution
- to apply the stabiliy analysis for systems with feedback control

Content

- Basic concepts of stability
- Lyapunov's functions
- Direct lyapunov's methods
- Stability of equilibria positions
- Attraction area of a stable solution
- Stability according to the first order approximation
- Systems with parametric excitation
- Stability criteria in the control theory

Literature

- Pannovko Y.G., Gubanova I.I. Stability and Oscillations of Elastic Systems, Paradoxes, Fallacies and New Concepts. Consultants Bureau, 1965.
- Hagedorn P. Nichtlineare Schwingungen. Akademische Verlagsgesellschaft, 1978.
- Thomsen J.J. Vibration and Stability, Order and Chaos. McGraw-Hill, 1997.

Course: Control Technology [2150683]

Coordinators: C. Gönnheimer
Part of the modules: SP 40: Robotics (p. 445)[SP_40_mach], SP 39: Production Technology (p. 443)[SP_39_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 04: Automation Technology (p. 409)[SP_04_mach], SP 02: Powertrain Systems (p. 407)[SP_02_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
The assessment is carried out as an oral exam. In case of a great number of participating students assessment is carried out as a written exam. Oral exams then are only carried out in the event of repetition.

Conditions
None

Recommendations
This course is geared to MSc students.

Learning Outcomes
The students . . .

- are able to name the electrical controls which occur in the industrial environment and explain their function.
- can explain fundamental methods of signal processing. This involves in particular several coding methods, error protection methods and analog to digital conversion.
- are able to choose and to dimension control components, including sensors and actors, for an industrial application, particularly in the field of plant engineering and machine tools. Thereby, they can consider both, technical and economical issues.
- can describe the approach for projecting and writing software programs for a programmable logic control named Simatic S7 from Siemens. Thereby they can name several programming languages of the IEC 1131.

Content
The lecture control technology gives an integral overview of available control components within the field of industrial production systems. The first part of the lecture deals with the fundamentals of signal processing and with control peripherals in the form of sensors and actors which are used in production systems for the detection and manipulation of process states. The second part handles with the function of electric control systems in the production environment. The main focus in this chapter is laid on programmable logic controls, computerized numerical controls and robot controls. Finally the course ends with the topic of cross-linking and decentralization with the help of bus systems.
The lecture is very practice-oriented and illustrated with numerous examples from different branches.
The following topics will be covered

- Signal processing
- Control peripherals
- Programmable logic controls
- Numerical controls
- Controls for industrial robots
- Process control systems
- Field bus
- Trends in the area of control technology

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Radiation Protection: Ionising Radiation [23271]

Coordinators: B. Breustedt, M. Urban
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach], SP 21: Nuclear Energy (p. 422)[SP_21_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
The assessment consists of an oral exam (approx. 20 minutes) according to sec. 4 subsec. 2 no. 2 study and examination regulations.

Conditions
None.

Learning Outcomes
The Students know about the basics of radiation protection concerning ionizing radiation.

Content
The lecture shows the basics of radiation protection concerning ionizing radiation.

Course: Strategic product development - identification of potentials of innovative products [2146198]

Coordinators: A. Siebe
Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 51: Development of innovative appliances and power tools (p. 457)[SP_51_mach], SP 10: Engineering Design (p. 412)[SP_10_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
oral exam
duration: 20 minutes

Conditions
none

Learning Outcomes
After listening to this lecture the students is able to ...

- describe the importance and goals of future management in product planning.
- to evaluate the different approaches of strategic product planning under consideration of the particular application.
- describe the approaches of a strategic szenario-based product planning.
- illustrate the strategic szenario-based product planning based on examples.

Content
Introduction into future management, Development of scenarios, scenariobased strategy development, trendmanagement, strategic early detection, innovation- and technologymanagement, scenarios in product development, from profiles of requirements to new products, examples out of industrial praxis.

Course: Flows with chemical reactions [2153406]

Coordinators: A. Class
Part of the modules: SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
Oral examination

Duration: 30 min
as WF NIE
written homework

Lecture

Conditions
None.

Recommendations
Mathematics

Learning Outcomes
The students can describe flow scenarios, where a chemical reaktion is confined to a thin layer. They can choose simplifying approaches for the underlying chemistry and discuss the problems with focus on the fluid mechanic aspects. The students are able to solve simple problems analytically. Furthermore, they are qualified to discuss simplifications as relevant for an efficent numerical solution of complex problems.

Content
In the lecture we mainly consider problems, where chemical reaktion is confined to a thin layer.
The problems are solved analytically or they are at least simplified allowing for efficent numerical sollution procedures. We apply simplified chemistry and focus on the fluid mechanic aspects of the problems.

Media
Black board

Literature
Lecture

Buckmaster, J.D.; Ludford, G.S.S.: Lectures on Mathematical Combustion, SIAM 1983

Course: Flows and Heat Transfer in Energy Technology [2189910]

Coordinators: X. Cheng
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 21: Nuclear Energy (p. 422)[SP_21_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral examination; duration: 20min

Conditions
None.

Learning Outcomes
This lecture is dedicated to students of mechanical engineering and other engineering Bachelor or Master degree courses. Goal of the lecture is the understanding of major processes in fluid dynamics and heat transfer in energy engineering. Through this lecture the students are capable of understanding the important physical processes and the selection of suitable methods for the analysis of the processes. With the discussion of some practical examples, the students can analyze the pressure drop and heat transfer in energy engineering systems.

Content

1. collection of sample applications
2. heat transfer and its application
3. convective fluid dynamics and heat transfer
4. thermal radiation and its application
5. special cases

Literature

- Bahr, H.D., Stephan, K., Wärme- und Stoffübertragung, 3. Auflage Springer Verlag, 1998
- Mueller, U., Zweiphasenströmung, Vorlesungsmanuskript, Februar 2000, TH Karlsruhe
- Mueller, U., Freie Konvektion und Wärmeübertragung, Vorlesungsmanuskript, WS1993/1994, TH Karlsruhe
- W. Oldekop,„Einführung in die Kernreaktor und Kernkraftwerktechnik,“Verlag Karl Thiemig, München, 1975
- Cacuci, D.G., Badea, A.F., Energiesysteme I, Vorlesungsmanuskript, 2006, TH Karlsruhe
- Jones, O.C., Nuclear Reactor Safety Heat Transfer, Hemisphere Verlag, 1981
- Herwig, H., Moschallski, A., Wärmeübertragung, 2. Auflage, Vieweg + Teubner, 2009

Course: Flow Simulations [2154447]

Coordinators: C. Bruzzese, B. Frohnapfel
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
homework and colloquium, both ungraded

Conditions
None.

Recommendations
Basics of fluid mechanics

Learning Outcomes
Students are able to use the basic functionality of the open source software OPENFOAM(R) for simulating laminar and turbulent flows (in RANS context). They know the setup and the process of a fluid mechanical simulation with OPENFOAM(R). The students are able to visualize the results and to question the plausibility of the results. They are able to build simple block-structured meshes and meshes of more complex three-dimensional domains. The students are aware of the sensitivity of the results of a flow simulation (meshing, numerical settings, turbulence model).

Content

- Basic elements of a simulation with OPENFOAM(R)
- Simulation of 'classic' incompressible, stationary/unstationary, laminar/turbulent (in RANS context) flows (special types of flows, e.g. reactive flows, multi-phase flows, magnetohydrodynamics, ... are not covered)
- Visualization of results
- Evaluation and interpretation of results
- Necessary basics of turbulence modelling with RANS models in OPENFOAM(R)
- Basics of the structure and the numerics of OPENFOAM(R) and possibilities for extending the software

Media
Solution of problems on a computer

Literature

- F. Moukalled, L. Mangani, M. Darwish: The Finite Volume Method in Computational Fluid Dynamics. Springer, 2016
- Further literature will be presented during the course

Remarks
Block course with limited number of participants, registration in the secretary's office required. See details at www.istm.kit.edu
(This offering is not approved or endorsed by OpenCFD Limited, producer and distributor of the OpenFOAM software via www.openfoam.com, and owner of the OPENFOAM(R) and OpenCFD(R) trade marks. OPENFOAM(R) is a registered trade mark of OpenCFD Limited, producer and distributor of the OpenFOAM software via www.openfoam.com.)

Course: Structural and phase analysis [2125763]

Coordinators: S. Wagner, M. Hinterstein
Part of the modules: SP 43: Technical Ceramics and Powder Materials (p. 449)[SP_43_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral
20 min
auxiliary means: none

Conditions
None.

Learning Outcomes
The students know the fundamentals of crystallography, the generation and detection of x-rays as well as their interaction with the microstructure of crystalline materials. They have detailed knowledge about the different methods of x-ray diffraction measurements and are able to analyse x-ray spectra using modern methods of x-ray analysis both qualitatively and quantitatively.

Content
The course gives an overview to generation and detection of x-rays as well as their interaction with matter. It provides an introduction to crystallography and describes modern measurement and analysis methods of x-ray diffraction.
It is arranged in the following units:

- Generation and properties of X-Ray's
- Crystallography
- Fundamentals and application of different measuring methods
- Qualitative and quantitative phase analysis
- Texture analysis (pole figures)
- Residual stress measurements

Media
Slides for the lecture:
available unter http://ilias.studium.kit.edu

Literature

1. Moderne Röntgenbeugung - Röntgendiffraktometrie für Materialwissenschaftler, Physiker und Chemiker, Spieß, Lothar / Schwarzer, Robert / Behnken, Herfried / Teichert, Gerd B.G. Teubner Verlag 2005
2. H. Krischner: Einführung in die Röntgenfeinstrukturanalyse. Vieweg 1990.
3. B.D. Cullity and S.R. Stock: Elements of X-ray diffraction. Prentice Hall New Jersey, 2001.

Course: Structural Analysis of Composite Laminates [2113106]

Coordinators: L. Kärger
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 30: Applied Mechanics (p. 434)[SP_30_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral 20-30 minutes
auxiliary means: none

Conditions
technical mechanics

Learning Outcomes
The students understand the mechanical correlation between fibre-matrix-configuration and macroscopic material behavior. They can formulate the stress-strain / force-strain relation of an individual layer and of a multilayer laminate by approaches of first and higher order. The students know and can interpret and apply failure criteria and approaches to model damage progression. They know simple dimension strategies to design FRP components.

Content
Micromechanics and Homogenization of fibre-matrix-composite
macromechanical behavior of individual layer
Behaviour of multilayer laminate
FE formulations
Failure criteria
damage analysis
Dimensioning of FRP parts

Literature
H. Altenbach, J. Altenbach, W. Kissing; Mechanics of Composite Structural Elements . ISBN 978-3-642-07411-0 Springer-Verlag Berlin Heidelberg, 2004.
E. J. Barbero: Finite Element Analysis of Composite Materials. ISBN: 1-4200-5433-3. CRC Press, Boca Raton, FL, 1. edition, 2008.
E. J. Barbero: Introduction to Composite Materials Design. CRC Press, Boca Raton, FL, 2. edition, 2011.
E. J. Barbero: Finite Element Analysis of Composite Materials Using Abaqus. ISBN: ISBN: 978-1-46-651661-8. CRC Press, Boca Raton, FL, 2013.
Isaac M. Daniel, Ori Ishai: Engineering Mechanics of Composite Materials. Oxford Univ Press; ISBN-13: 978-0195150971, 2. Edition, 2005.
Davila, C. G.; Camanho, P. P.; Rose, C. A.: Failure criteria for FRP laminates. Journal of Composite Materials 39: 323-345, 2005.
Hinton, M. J.; Kaddour, A. S.; Soden, P. D.: A comparison of the predictive capabilities of current failure theories for composite laminates, judged against experimental evidence. Composites Science and Technology 62: 1725-1797, 2002.
Puck, A.; Schürmann, H.: Failure analysis of FRP laminates by means of physically based phenomenological models. Composite Science and Technology 58: 1045-1067, 1998.
Reddy, J. N.: Mechanics of laminated composite plates and shells - Theory and Analysis. USA: CRC Press, Boca Raton, 2004.
Soden, P. D.; Kaddour, A. S.; Hinton, M. J.: Recommendations for designers and researchers resulting from the world-wide failure exercise. Composites Science and Technology 64: 589-604, 2004.
Stephen W. Tsai and J. Daniel D. Melo: Composite Materials Design and Testing. Composites Design Group, 978-0-9860845-1-5 Stanford University , 2015.

Course: Structural Ceramics [2126775]

Coordinators: M. Hoffmann
Part of the modules: SP 43: Technical Ceramics and Powder Materials (p. 449)[SP_43_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
The assessment consists of an oral exam (20 min) taking place at a specific date.
Auxiliary means: none
The re-examination is offered at a specific date.

Conditions
none

Recommendations
Basics of the course “Introduction to Ceramics” should be known.

Learning Outcomes
The students know the most relevant structural ceramics (silicon carbide, silicon nitride, alumina, boron nitride, zirconia, fibre-reinforced ceramics) and their applications. They are familar with the microstructural features, fabrication methods, and mechanical properties.

Content
The lecture gives an overview on structure and properties of the technical relevant structural ceramics silicon nitride, silicon carbide, alumina, zirconia, boron nitride and fibre-reinforced ceramics. All types of structural ceramics will be discussed in detail in terms of preparation methods of the raw materials, shaping techniques, densification, microstructural development, mechanical properties and application fields.

Media
Slides for the lecture:
available under http://ilias.studium.kit.edu

Literature
W.D. Kingery, H.K. Bowen, D.R. Uhlmann, “Introduction to Ceramics”, John Wiley & Sons, New York, (1976)

E. Dörre, H. Hübner, “Aluminia”, Springer Verlag Berlin, (1984)

M. Barsoum, “Fundamentals of Ceramics”, McGraw-Hill Series in Material Science and Enginewering (2003)

Remarks
The course will not take place every year.

Course: Superhard Thin Film Materials [2177618]

Coordinators: S. Ulrich
Part of the modules: SP 47: Tribology (p. 453)[SP_47_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral examination (30 min)

no tools or reference materials

Conditions
None

Recommendations
None

Learning Outcomes
Superhard materials are solids with a hardness higher than 4000 HV 0,05. The main topics of this lecture are modelling, deposition, characterization and application of superhard thin film materials.

Content
Introduction

Basics

Plasma diagnostics

Particle flux analysis

Sputtering and ion implantation

Computer simulations

Properties of materials, thin film deposition technology,
thin film analysis and modelling of superhard materials

Amorphous hydrogenated carbon

Diamond like carbon

Diamond

Cubic Boronnitride

Materials of the system metall-boron-carbon-nitrogen-silicon

Literature
G. Kienel (Ed.): Vakuumbeschichtung 1 - 5, VDI Verlag, Düsseldorf, 1994

Copies with figures and tables will be distributed

Course: Supply chain management [2117062]

Coordinators: K. Alicke
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach], SP 19: Information Technology of Logistic Systems (p. 420)[SP_19_mach], SP 29: Logistics and Material Flow Theory (p. 433)[SP_29_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	4	Winter term	de

Learning Control / Examinations
oral examination

No tools or reference materials may be used during the exam.

Conditions
None.

Recommendations
none

Learning Outcomes
Students are able to:

- Discuss the requirements on modern supply chains,
- Use the basic concepts of demand forecast, stock optimization and supply in practical exercises,
- Analyse the typical questions of dimensioning a supply chain and evaluate a supply chain with the results.

Content

- Bullwhip-Effect, Demand Planning & Forecasting
- Conventional planning processes (MRP + MRPII)
- Stock keeping strategy
- Data acquisition and analysis
- Design for logistics (Postponement, Mass Customization, etc.)
- Logistic partnerships (VMI, etc.)
- Distribution structures (central vs. distributed, Hub&Spoke)
- SCM-metrics (performance measurement) e-business
- Special sectors as well as guest lectures

Media
presentations

Literature
Alicke, K.: Planung und Betrieb von Logistiknetzwerken

Simchi-Levi, D., Kaminsky, P.: Designing and Managing the Supply Chain

Goldratt, E., Cox, J.: The Goal

Remarks
this course is not offered at the moment
this course is a block course
limited number: application necessary

Course: Sustainable Product Engineering [2146192]

Coordinators: K. Ziegahn

Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 10: Engineering Design (p. 412)[SP_10_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	

Learning Control / Examinations

The type of examination (written or oral) will be announced at the beginning of the lecture.
written examination: 60 min duration
oral examination: 20 min duration

Conditions

none

Learning Outcomes

The goal of the lecture is to convey the main elements of sustainable product development in the economic, social and ecological context.
The students are able to ...

- identify und describe the sustainability objectives and their role in product development, the interaction between technical products and their environment, the holistic approach and the equality of economic, social and environmental aspects and environmental aspects.
- discuss the skills for life-cycle product design using the example of complex automotive components such as airbag systems and other current products.
- understand the product environmental stresses with relevancy to praxis at the example of technology-intensive components, robustness and durability of products as the basis for a sustainable product development, development of skills for the application of environmental simulationduring the process of developement of technical products.
- develop skills such as team skills / project / self / presentation based on realistic projects.

Content

understanding of sustainability objectives and their role in product development, the interaction between technical products and their environment, the holistic approach and the equality of economic, social and environmental aspects and environmental aspects
skills for life-cycle product design using the example of complex automotive components such as airbag systems and other current products
understanding of product environmental stresses with relevancy to praxis at the example of technology-intensive components, robustness and durability of products as the basis for a sustainable product development, development of skills for the application of environmental simulationduring the process of developement of technical products
delivery of key skills such as team skills / project / self / presentation based on realistic projects

Course: System Integration in Micro- and Nanotechnology [2106033]

Coordinators: U. Gengenbach
Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 32: Medical Technology (p. 437)[SP_32_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 54: Microactuators and Microsensors (p. 459)[SP_54_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
oral

Conditions
None.

Learning Outcomes
Students acquire fundamental knowledge about challenges and system integration processes.

Content

- Introduction
- Definition system integration
- Integration of mechanical functions (flexures)
- Plasma treatment of surfaces
- Adhesive bonding
  - Packaging
  - Low Temperature Cofired Ceramics (LTCC)
  - Assembly of hybrid systems
- Monolithic/hybrid system integration)
- Modular system integration
- Integration of electrical/electronic functions
- Mounting techniques
- molded Interconnect Devices (MID)
- Functional printing
- Coating
- Capping
- Housing

First steps towards system integration nanotechnology

Literature

- A. Risse, Fertigungsverfahren der Mechatronik, Feinwerk- und Präzisionsgerätetechnik, Vieweg+Teubner Verlag Wiesbaden, 2012
- M. Madou, Fundamentals of microfabrication and nanotechnology, CRC Press Boca raton, 2012
- G. Habenicht, Kleben Grundlagen, Technologien, Anwendungen, Springer-Verlag Berlin Heidelberg, 2009
- J. Franke, Räumliche elektronische Baugruppen (3D-MID), Carl Hanser-Verlag München, 2013

Course: Technical Acoustics [2158107]

Coordinators: M. Gabi
Part of the modules: SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 10: Engineering Design (p. 412)[SP_10_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
Oral examination
Duration: 30 minutes
No tools or reference materials may be used during the exam.

Conditions
none

Recommendations
none

Learning Outcomes
Students get to know the basics of technical acoustics in general. Application of the knowledge in different fields of engineering.
Students learn physical basics of acoustics and human perception. Physical-empirical laws for determination of sound and noise levels of various emission and immission situations will be worked out or derived. Furtheron general sound measurement methods of machinery will be taught.
Students are able to understand mechanisms of sound origin, propagation and reduction, as well as measuring technics

Content
Basics of acoustics
Perception and weighting of noise (human hearing)
Description of acoustic parameters, level notation
Noise propagation
Acoustical measurement techniques

Literature
1. Lecture notes (downloadable from institute's homepage).
2. Heckl, M.; Müller, H. A.: Taschenbuch der Technischen Akustik, Springer-Verlag.
3. Veit, Ivar: Technische Akustik. Vogel-Verlag (Kamprath-Reihe), Würzburg.
4. Henn, H. et al.: Ingenieurakustik. Vieweg-Verlag.

Course: Technical energy systems for buildings 1: Processes & components [2157200]

Coordinators: F. Schmidt
Part of the modules: SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations

Conditions
Can not be combined with the lecture Energy and indoor climate concepts for high performance buildings [1720997]

Learning Outcomes

Content

Course: Technical energy systems for buildings 2: System concepts [2158201]

Coordinators: F. Schmidt
Part of the modules: SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations

Conditions
Can not be combined with the lecture Energy and indoor climate concepts for high performance buildings [1720997]

Learning Outcomes

Content

Course: Computer Engineering [2106002]

Coordinators: M. Lorch, H. Keller
Part of the modules: SP 40: Robotics (p. 445)[SP_40_mach], SP 18: Information Technology (p. 419)[SP_18_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	de

Learning Control / Examinations
Written examination

Duration: 2 hours (compulsory subject)

Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students possess essential knowledge about information processing in digital computers. Based on information representation and calculations of complexity, students are capable to design algorithms efficiently. The students are able to apply the knowledge about efficient algorithm design to important numerical computation methods in mechanical engineering. Students have basic knowledge of real-time systems and their development. Students can use the knowledge to develop real-time systems for reliable automation of technological systems in mechanical engineering.

Content
Introduction: definitions, basic concepts, introductory examples

Information coding on finite automata: numbers, characters, commands, examples

Algorithm design: definitions, complexity of algorithms, complexity classes P and NP, examples

Sorting algorithms: relevance, algorithms, simplifications, examples

Software quality assurance: terms and measures, errors, phases of quality assurance, constructive measures, analytical measures, certification

Lectures are complemented by an exercice course.

Literature
Lecture Notes (Ilias)

Becker, B., Molitor, P.: Technische Informatik : eine einführende Darstellung. München, Wien : Oldenbourg, 2008.

Hoffmann, D. W.: Grundlagen der Technischen Informatik. München: Hanser, 2007.

Balzert, H.: Lehrbuch Grundlagen der Informatik : Konzepte und Notationen in UML, Java und C++, Algorithmik und Software-Technik, Anwendungen. Heidelberg, Berlin : Spektrum, Akad. Verl., 1999.

Trauboth, H.: Software-Qualitätssicherung : konstruktive und analytische Maßnahmen. München, Wien : Oldenbourg, 1993.
Ada Reference Manual, ISO/IEC 8652:2012(E), Language and Standard Libraries. Springer Heidelberg
Benra, J.; Keller, H.B.; Schiedermeier, G.; Tempelmeier, T.: Synchronisation und Konsistenz in Echtzeitsystemen. Benra, J.T. [Hrsg.] Software-Entwicklung für Echtzeitsysteme Berlin [u.a.] : Springer, 2009, S.49-65

Färber, G.:Prozeßrechentechnik. Springer-Lehrbuch. Springer; Auflage: 3., überarb. Aufl. (7. September 1994)
Leitfaden Informationssicherheit, IT-Grundschutz kompakt. Bundesamt für Sicherheit in der Informationstechnik – BSI53133 Bonn, 2012, BSI-Bro12/311
Cooling, J.: Software Engineering for Real Time Systems. Addison-Wesley, Pearson, Harlow, 2002.
Stallings, W.: Betriebssysteme. 4. Auflage. Pearson Studium, München, 2003.
Summerville, I.: Software Engineering. Pearson Studium, München, 2007.

Course: Vibration Theory [2161212]

Coordinators: A. Fidlin
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach], (p. 465)[SP_60_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach]

ECTS Credits	Hours per week	Term	Instruction language
5	3	Winter term	de

Learning Control / Examinations
Written exam

Conditions
None.

Recommendations
Examen in Engineering Mechanics 3 + 4

Learning Outcomes
The course gives an introduction into the vibration theory of linear systems. First, general vibration in form of harmonic signals is considered. One degree of freedom systems are treated in detail for free and forced vibration, especially for harmonic, periodic and arbitrary excitation. This is the foundation for systems with many degrees of freedom as these may be transformed with the help of modal coordinates. For multiple dof systems the eigenvalue problem is solved. Then forced vibration is treated. Finally, wave propagation problems and eigenvalue problems for systems with distributed parameters are discussed. As an application an introduction into rotor dynamics is given.

Goal of the course is to see the similarities for systems with one dof and with multiple dof. Besides typical phenomena like resonance a systematic mathematical approach to vibration problems and an interpretation of the mathematical results should be obtained.

Content
Concept of vibration, superposition of vibration with equal and with different frequencies, complex frequency response.

Vibration of systems with one dof: Free undamped and damped vibration, forced vibration for harmonic, periodic and arbitrary excitation. Excitation of undamped vibration in resonance.

Systems with many degrees of freedom: Eigenvalue problem for undamped vibration, orthogonality of eigenvectors, modal decoupling, approximation methods, eigenvalue problem for damped vibration. Forced vibration for harmonic excitation, modal decomposition for arbitrary forced vibration, vibration absorber.

Vibration of systems with distributed parameters: Partial differential equations as equations of motion, wave propagation, d'Alembert's solution, Ansatz for separation of time and space, eigenvalue problem, infinite number of eigenvalues and eigenfunctions.

Introduction to rotor dynamics: Laval rotor in rigid and elastic bearings, inner damping, Laval rotor in anisotropic bearings, synchronous and asynchronous whirl, rotors with asymmetric shaft.

Literature
Klotter: Technische Schwingungslehre, Bd. 1 Teil A, Heidelberg, 1978

Hagedorn, Otterbein: Technische Schwingungslehre, Bd 1 and Bd 2, Berlin, 1987

Wittenburg: Schwingungslehre, Springer-Verlag, Berlin, 1995

Course: Technical Design in Product Development [2146179]

Coordinators: M. Schmid
Part of the modules: SP 03: Man - Technology - Organisation (p. 408)[SP_03_mach], SP 10: Engineering Design (p. 412)[SP_10_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
For the reason of high student number the exam is a written exam.
Only dictionnary is allowed.

Conditions
none

Recommendations
None

Learning Outcomes
In the Technical Design module, at the end of the lecture, students acquire knowledge of the essential basics of technically oriented design as an integral part of methodological product development. A strong focus is on the user-centered design of the man-machine interface as the basis for a holistic product design.
The students have knowledge about ...

- acquire well-founded design knowledge for use at the interface between engineer and designer
- acquire knowledge about the integration of design into the design development process.
- acquire all relevant human-product requirements that are derived from the bidirectional information flow between man and machine.
- master evaluation processes with regard to solution-independent fixed, divisional and desired requirements and their different weighting to determine usability factors in the context of the product.
- acquire a better understanding of the transfer of theoretical knowledge into practical product designs using a consistent example.

Content
preface
Value-relevant parameters of the technical design
Interface Design Basics
Macroergonomics: Planning and concept phase
Microergonomics: concept and design phase
Microergonomics: Development phase
best practice

Literature
Inhalt:
Einleitung
Wertrelevante Parameter des Technischen Design
Grundlagen Interface-Design
Makroergonomie: Planung- u. Konzeptphase
Mikroergonomie: Konzept- u. Entwurfsphase
Mikroergonomie: Ausarbeitungsphase
Best Practice
Literatur:
Markus Schmid, Thomas Maier
Technisches Interface Design
Anforderungen, Bewertung, Gestaltung.
Springer Vieweg Verlag

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Design technischer Produkte, Produktprogramme und -systeme
Industrial Design Engineering.
2. , bearb. und erweiterte Auflage.
Springer-Verlag GmbH
ISBN: 3540236538
September 2005 - gebunden - 396 Seiten

Course: Technology of steel components [2174579]

Coordinators: V. Schulze
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
Materials Science I & II

Learning Outcomes
The students have the background to evaluate the influence of manufacture processes on the compound state of metallic compounds. The students can assess the influence and the stability of compound state under mechanical load. The students are capable to describe the individual aspects of interaction of the compound state of steel components due to forming, heat treatment, mechanical surface treatment and joining processes.

Content
Meaning, Development and characterization of component states
Description of the influence of component state on mechanical properties
Stability of component states
Steel manufacturing
Component states due to forming
Component states due to heat treatments
Component states due to surface hardening
Component states due to machining
Component states due to mechanical surface treatments
Component states due to joining
Summarizing evaluation

Literature
Script will be distributed within the lecture
VDEh: Werkstoffkunde Stahl, Bd. 1: Grundlagen, Springer-Verlag, 1984
H.-J. Eckstein: Technologie der Wärmebehandlung von Stahl, Deutscher Verlag Grundstoffindustrie, 1977
H.K.D.H. Badeshia, R.W.K. Honeycombe, Steels - Microstructure and Properties, CIMA Publishing, 3. Auflage, 2006
V. Schulze: Modern Mechanical Surface Treatments, Wiley, Weinheim, 2005

Course: Ten lectures on turbulence [2189904]

Coordinators: I. Otic
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach], SP 21: Nuclear Energy (p. 422)[SP_21_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	en

Learning Control / Examinations
oral examination; duration: 20 minutes

Conditions
None.

Recommendations

- Undergraduate statistics and probability theory. Graduate-level fluid mechanics.

Learning Outcomes
At the completion of this course, students
- are able to understand fundamentals of statistical fluid mechanics, turbulence theory and turbulence modelling
- are able to derive RANS and LES transport equations
- get working knowledge of modelling techniques that can be used for solving engineering heat and mass transfer problems.

Content
The course is aimed of giving the fundamentals of turbelence theory, modelling and simulation. Governing equations and statistical description of turbulence are introduced. Reynolds equations, Kolmogorov's theory and scales of turbulent ows are discussed. Homogeneous and isotropic turbulence. Turbulent free-shear ows and wall-bounded turbulent ows are discussed. Turbulence modelling approaches and simulation methods are introduced.

Literature
Reference texts:
- Lecture Notes
- Presentation slides
Recommended Books:
- Pope, S. B.: Turbulent Flows. Cambridge University Press , 2003.
- Hinze J. O.: Turbulence. McGraw-Hill, 1975.

Course: Materials under high thermal or neutron loads [2194650]

Coordinators: A. Möslang, J. Reiser
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach], SP 21: Nuclear Energy (p. 422)[SP_21_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
Oral Examination (20 min)

Conditions
Materials science I

Recommendations
none

Learning Outcomes
Advanced structural and functional materials for thermally or neutronically highly loaded systems. The students learn property profiles, applications and the interaction between atomic structure, microstructure and macroscopic materials behaviour.

Content
- Introduction and basics
- Metallic and ceramic solid state structure
- Transport of mater and conversion in solid state
- Material properties at high heat leoads
- Interaction between energetic particles and condensed matter, irradiation damage
- Nanoscaled modelling of damage relevant properties
- State-of-the-art analytical methods with particles
- Highly heat resistant Steels
- Nanoscaled, oxide dispersion strengthened alloys
- Super alloys
- Refractory metals and laminates
- Fibre reinforced structural ceramics
- Light high strength Beryllium alloys
- Oxides and functional materials
- Joining technologies
- Strategies of materials development
- Applications in Fusion, fission, large scale accelerators and concentrated solar power

Literature
Presentation with figures and tables, Exercise sheets

Course: Thermal Solar Energy [2169472]

Coordinators: R. Stieglitz
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral
Duration: approximately 25 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
desirbale are reliable knowledge in physics in optics and thermodynamics
Basics in heat and mass transfer, material science, energy technology and fluid mechanics

Learning Outcomes
The lecture elaborates the basics of the solar technology and the definition of the major wordings and its phyical content such as radiation, thermal use, insulation etc.. Further the design of solar collectors for different purposes is discussed and analyzed. The functional principle of solar plants is elaborated before at the ende the ways for solar climatization is discussed.
The aim of the course is to provide the basic physical principles and the derivation of key parameters for the individual solar thermal use. This involves in addition to the selective absorber, mirrors, glasses, and storage technology. In addition, a utilization of solar thermal energy means an interlink of the collector with a thermal-hydraulic circuit and a storage. The goal is to capture the regularities of linking to derive efficiency correlations as a function of their use and evaluate the performance of the entire system.

Content
Baiscs of thermal solar energy (radiation, heat conduction, storage, efficiency ....) Active and passive use of solar energy. Solar collectors (design types, efficiency, system technology). Solar plants (heliostats etc.). Solar climatization.
In detail:

1 Introduction to energy requirements and evaluation of the potential use of solar thermal energy.

2 Primary energy sources SUN: sun, solar constant, radiation (direct, diffuse scattering, absorption, impact angle, radiation balance).

3 Solar panels: schematic structure of a collector, fundamentals of efficiency, meaning of concentration and their limitations.

4 Passive solar mechanisms: heat conduction in solids and gases, radiation heat transfer in transparent and opaque bodies, selective absorber - typical materials and manufacturing processes.

5 Momentum and heat transport: basic equations of single and multiphase transport, calculation methods, stability limits.

optional

6 Low temperature solar thermal systems: Collector variants, methods for system simulation, planning and dimensioning of systems, system design and arrest scenarios.

6 High temperature solar thermal systems: solar towers and solar-farm concept, loss mechanisms, chimney

power plants and energy production processes

end

- Memory: energy content, storage types, storage materials, cost
- Solar Air Conditioning: Cooling capacity determination, climate, solar cooling method and evaluation of air conditioning.

Media
Präsentation complemented by printouts

Literature
supply of lecture material in printed and electronic form
Stieglitz & Heinzel; Thermische Solarenergie -Grundlagen-Technologie- Anwendungen. Springer Vieweg Verlag. 711 Seiten. ISBN 978-3-642-29474-7

Course: Thermal Turbomachines I [2169453]

Coordinators: H. Bauer
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Winter term	de

Learning Control / Examinations
oral
Duration: approximately 30 min

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Recommended in combination with the lecture 'Thermal Turbomachines II'.

Learning Outcomes
The students are able to explain and comment on the design and operation of thermal turbomachines in detail. Moreover, they can evaluate the range of applications for turbomachinery. Therefore, students are able to describe and analyse not only the individual components but also entire assemblies. The students can asses and evaluate the effects of physical, economical and ecological boundary conditions.

Content
Basic concepts of thermal turbomachinery

Steam Turbines - Thermodynamic process analysis

Gas Turbines - Thermodynamic process analysis

Combined cycle and cogeneration processes

Overview of turbomachinery theory and kinematics

Energy transfer process within a turbine stage

Types of turbines (presented through examples)

1-D streamline analysis techniques

3-D flow fields and radial momentum equilibrium in turbines

Compressor stage analysis and future trends in turbomachinery

Literature
Lecture notes (available via Internet)

Bohl, W.: Strömungsmaschinen, Bd. I, II; Vogel Verlag, 1990, 1991

Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993

Traupel, W.: Thermische Turbomaschinen Bd. I, II, Springer-Verlag, 1977, 1982

Course: Thermal Turbomachines II [2170476]

Coordinators: H. Bauer
Part of the modules: SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	3	Summer term	en

Learning Control / Examinations
oral examination

Conditions
None.

Recommendations
Recommended in combination with the lecture 'Thermal Turbomachines I'.

Learning Outcomes
Based on the fundamental skills learned in 'Thermal Turbomachines I' the students have the ability to design turbines and compressors and to analyse the operational behavior of these machines.

Content
General overview, trends in design and development

Comparison turbine - compressor

Integrating resume of losses

Principal equations and correlations in turbine and compressor design, stage performance

Off-design performance of multi-stage turbomachines

Control system considerations for steam and gas turbines

Components of turbomachines

Critical components

Materials for turbine blades

Cooling methods for turbine blades (steam and air cooling methods)

Short overview of power plant operation

Combustion chamber and environmental issues

Literature
Lecture notes (Available via internet)
Bohl, W.: Strömungsmaschinen, Bd. I,II, Vogel Verlag 1990, 1991
Sigloch, H.: Strömungsmaschinen, Carl Hanser Verlag, 1993
Traupel, W.: Thermische Turbomaschinen, Bd. I,II, Springer-Verlag, 1977, 1982

Course: Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises) [2193002]

Coordinators: H. Seifert
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

ECTS Credits	Hours per week	Term	Instruction language
5	2	Winter term	de

Learning Control / Examinations
Oral examination (30 min)

Conditions
Knowledge of the course “Solid State Reactions and Kinetics of Phase Transformations” (Franke)

Recommendations

- basic course in materials science and engineering
- basic course in mathematics
- physics or physical chemistry

Learning Outcomes
The students know the heterogeneous phase equilibria of binary, ternary and multicomponent materials systems. They can analyze the thermodynamic properties of multiphase engineering materials and their reactions with gas and liquid phases.

Content
1. Binary phase diagrams
2. Ternary phase diagrams
- Complete solubility
- Eutectic systems
- Peritectic systems
- Systems with transition reactions
- Systems with intermetallic phases
3. Thermodynamics of solution phases
4. Materials reactions involving pure condensed phases and a gaseous phase
5. Reaction equilibria in systems containing components in condensed solutions
6. Thermodynamics of multicomponent multiphase materials systems
7. Calculation of Phase Diagrams (CALPHAD)

Literature
1. Phase Equilibria, Phase Diagrams and Phase Transformations, Their Thermodynamic Basis; M. Hillert, University Press, Cambridge (2007)
2. Introduction to the Thermodynamics of Materials; D.R. Gaskell, Taylor & Francis (2008)

Course: Thermal-Fluid-Dynamics [2189423]

Coordinators: S. Ruck
Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 53: Fusion Technology (p. 458)[SP_53_mach], SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral exam

Conditions
none

Learning Outcomes
The objectives of the lecture are the fundamentals of thermal-hydraulics for describing and evaluating convective turbulent transport processes as occurring in power engineering components. The major objective is a description of the convective heat transfer for external and internal flows. A central point is the transfer of analytic models to "state of the art" computational tools and the corresponding validation by advanced experimental methods. Beyond the superior goals the students shall be enabled (a) to develop differential equation of thermal-hydraulic transport and evolve dimensionless parameters (b) to transfer a real problem to an experimental or numerical model (c) to develop analogies and correlations for heat transfer processes of forced convection, (d) to select adequate computational methods/models and (e) to evaluate and select experiments including measurement techniques with adequate instrumentation for thermal-hydraulic problems.

Content
The lecture provides an overview of momentum and energy transport as occurring in power engineering components and heat exchangers. Conservation equations are discussed. Based on the fundamentals of thermal-hydraulics, dimensionless parameters for forced and free convection are evolved. The statistical concepts for describing turbulent flows and the corresponding transport equations are introduced. Analysis of thermal and turbulent measurement signals are discussed.
Flows close to walls play a crucial role for the convective heat transfer and for heat exchanger components. Thus, the thermal boundary layer equations are introduced for the laminar and turbulent case. Velocity and temperature laws of the wall as a basis for analogies and models of computational tools are discussed; turbulence modelling and scale-resolving methods and their applicability for different conditions or heat transfer fluids are described in the following. Analogies and correlations for internal and external forced convection are developed by means of approximation concepts. Furthermore, design options to enhance the efficiency of heat exchangers are discussed. Solution strategies and best practical guidelines of the aforementioned methods are provided.
Main Issues

- Fundamentals of flows and heat transfer
- Dimensionless parameters of thermal fluid dynamics
- Statistic description and analytics of turbulent flows
- Thermal boundary layer equations
- Velocity and temperature laws in boundary layers
- Convective Heat transfer of external and internal flows
- Analogies (Prandtl-, von Kárman, Martinelli,. . .)
- Methods for enhancing heat transfer
- Strategies and methods for experimental and numerical investigation of thermal-hydraulics in R&D

Literature
Literatures are specified in the corresponding lectures. Teaching materials are provided online at http://ilias.studium.kit.edu. Hardcopy script for special topics during the lecture.

Course: Thin film and small-scale mechanical behavior [2178123]

Coordinators: P. Gruber, D. Weygand, C. Brandl
Part of the modules: SP 56: Advanced Materials Modelling (p. 461)[SP_56_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	en

Learning Control / Examinations
oral exam 30 minutes

Conditions
none

Recommendations
preliminary knowlegde in materials science, physics and mathematics

Learning Outcomes
The students know and understand size and scaling effects in micro- and nanosystems. They can describe the mechanical behavior of nano- and microstructured materials and analyze and explain the origin for the differences compared to classical material behavior. They are able to explain suitable processing routes, experimental characterization techniques and adequate modelling schemes for nano- and microstructured materials.

Content
1. Introduction: Application and properties of micro- and nanosystems
2. Physical scaling and size effects
3. Fundamentals: Dislocation plasticity and microstructure
4. Thin films
5. Strain gradient plasticity
6. Micro- and nanosamples: Nanowires, micropillars, microbeams
7. Nanocrystalline materials
8. Multilayer systems

Media
Lecture slides

Literature
1. M. Ohring: „The Materials Science of Thin Films“, Academic Press, 1992
2. L.B. Freund and S. Suresh: „Thin Film Materials“

Course: Tractors [2113080]

Coordinators: M. Kremmer, M. Scherer
Part of the modules: SP 34: Mobile Machines (p. 441)[SP_34_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
The assessment consists of an oral exam taking place in the recess period. The exam takes place only after the winter semester. Re-examinations are offered solely during this examination period.

Conditions
None.

Recommendations
basic knowledge in mechanical engineering

Learning Outcomes
After completion of the course the Students know:

- important problems in agritechnological developments
- Customer requirements and their implementation in tractors
- Tractor technology in width and depth

Content
Tractors are one of the most underestimated vehicles in regard to performance und technics. Almost none vehicle is as multifunctional and fullfilled with high-tec as a tractor. Automatic guidance, special chassis suspension or special concepts of power trains are one of the topics where tractors are in leading position in technologies

During the lecture an overview about the design and construction and application area is given. A close look will be taken on the historical backround, legal requirements, ways of development, agricultural organizations and the proces of development itself.

In detail the following topics will be dealt with:

- agricultural organization / legal requirements
- history of tractors
- tractor engineering
- tractor mechanics
- chassis suspension
- combustion engine
- transmission
- interfaces
- hydraulics
- wheels and tyres
- cabin
- electrics and electronics

Literature

- K.T. Renius: Traktoren - Technik und ihre Anwendung; DLG Verlag (Frankfurt), 1985
- E. Schilling: Landmaschinen - Lehr- und Handbuch für den Landmaschinenbau; Schilling-Verlag (Köln), 1960

Course: Tribology [2181114]

Coordinators: M. Dienwiebel
Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 47: Tribology (p. 453)[SP_47_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	5	Winter term	de

Learning Control / Examinations
oral examination (ca. 40 min)

no tools or reference materials
admission to the exam only with successful completion of the exercises

Conditions
None.

Recommendations
preliminary knowlegde in mathematics, mechanics and materials science

Learning Outcomes
The student can

- describe the fundamental friction and wear mechanisms, which occur in tribologically stressed systems
- evaluate the friction and wear behavior of tribological systems
- explain the effects of lubricants and their most important additives
- identify suitable approaches to optimize tribological systems
- explain the most important experimental methods for the measurement of friction and wear, and is able to use them for the characterisation of tribo pairs
- choose suitable methods for the evaluation of roughness and topography from the nm-scale to the mm-scale and is able to interpret the determined values in respect to their effect on the tribological behavior
- describe the most important surface-analytical methods and their physical principles for the characterization of tribologically stressed sliding surfaces

Content

- Chapter 1: Friction
adhesion, geometrical and real area of contact, Friction experiments, friction powder, tribological stressing, evironmental influences, tribological age, contact models, Simulation of contacts, roughness.
- Chapter 2: Wear
plastic deformation at the asperity level, dissipation modes, mechanical mixing, Dynamics of the third body, running-in, running- in dynamics, shear stress.
- Chapter 3: Lubrication
base oils, Stribeck plot, lubrication regimes (HD, EHD, mixed lubrication), additives, oil characterization, solid lubrication.
- Chapter 4: Measurement Techniques
friction measurement, tribometer, dissipated frictional power, conventional wear measurement, continuous wear measurement(RNT)
- Chapter 5: Roughness
profilometry, surface roughness parameters, evaluation length and filters, bearing ratio curve, measurement error

- Chapter 6: Accompanying Analysis
  multi-scale topography measurement, chemical surface analysis, structural analysis, mechanical analysis

Exercises are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students.

Literature

1. Fleischer, G. ; Gröger, H. ; Thum: Verschleiß und Zuverlässigkeit. 1. Auflage. Berlin : VEB-Verlag Technik, 1980
2. Persson, B.J.N.: Sliding Friction, Springer Verlag Berlin, 1998
3. M. Dienwiebel, and M. Scherge, Nanotribology in automotive industry, In:Fundamentals of Friction and Wear on the Nanoscale; Editors: E. Meyer and E. Gnecco, Springer, Berlin, 2007.
4. Scherge, M., Shakhvorostov, D., Pöhlmann, K.: Fundamental wear mechanism of metals. Wear 255, 395–400 (2003)
5. Shakhvorostov, D., Pöhlmann, K., Scherge, M.: An energetic approach to friction, wear and temperature. Wear 257, 124–130 (2004)

Course: Turbine and compressor Design [2169462]

Coordinators: H. Bauer, A. Schulz
Part of the modules: SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
Thermal Turbomachines I+II

Learning Outcomes
The students have the ability to:

- describe special types of components, such as e.g. radial machines and transonic compressors
- explain and evaluate the operation of components and machines
- interpret and apply the the physical principles
- design individual components in a practical approach

Content
The lecture is intended to expand the knowledge from Thermal Turbomachines I+II.
Thermal Turbomaschines, general overview

Design of a turbomachine: Criteria and development

Radial machines

Transonic compressors

Combustion chambers

Multi-spool installations

Literature
Münzberg, H.G.: Gasturbinen - Betriebsverhalten und Optimierung, Springer Verlag, 1977

Traupel, W.: Thermische Turbomaschinen, Bd. I-II, Springer Verlang, 1977, 1982

Course: Turbo Jet Engines [2170478]

Coordinators: H. Bauer, A. Schulz
Part of the modules: SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes
The students have the ability to:

- compare the design concepts of modern jet engines
- analyse the operation of modern jet engines
- apply the thermodynamic and fluidmechanic basics of jet engines
- choose the main components intake, compressor, combustor, turbine and thrust nozzle based on given criteria
- comment on different methods for the reduction of pollutant emissions, noise and fuel consumption

Content
Introduction to jet engines and their components

Demands on engines and propulsive efficiency

Thermodynamic and gas dynamic fundamentals and design calculations

Components of air breathing engines

Jet engine design and development process

Engine and component design

Current developments in the jet engines industry

Literature
Hagen, H.: Fluggasturbinen und ihre Leistungen, G. Braun Verlag, 1982
Hünnecke, K.: Flugtriebwerke, ihre Technik und Funktion, Motorbuch Verlag, 1993
Saravanamuttoo, H.; Rogers, G.; Cohen, H.: Gas Turbine Theory, 5th Ed., 04/2001
Rolls-Royce: The Jet Engine, ISBN:0902121235, 2005

Course: Metal Forming [2150681]

Coordinators: T. Herlan
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students

- are able to reflect the basics, forming processes, tools, Machines and equipment of metal forming in an integrated and systematic way.
- are capable to illustrate the differences between the forming processes, tools, machines and equipment with concrete examples and are qualified to analyze and assess them in terms of their suitability for the particular application.
- are also able to transfer and apply the acquired knowledge to other metal forming problems.

Content
At the beginning of the lecture the basics of metal forming are briefly introduced. The focus of the lecture is on massive forming (forging, extrusion, rolling) and sheet forming (car body forming, deep drawing, stretch drawing). This includes the systematic treatment of the appropriate metal forming Machines and the corresponding tool technology.
Aspects of tribology, as well as basics in material science and aspects of production planning are also discussed briefly. The plastic theory is presented to the extent necessary in order to present the numerical simulation method and the FEM computation of forming processes or tool design. The lecture will be completed by product samples from the forming technology.
The topics are as follows:

- Introduction and basics
- Hot forming
- Metal forming machines
- Tools
- Metallographic fundamentals
- Plastic theory
- Tribology
- Sheet forming
- Extrusion
- Numerical simulation

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Vacuum and Tritium Technology in Nuclear Fusion [2190499]

Coordinators: C. Day, B. Bornschein
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
oral examination, 20 Minutes, any time in the year

Conditions
none

Recommendations
Knowledge in ´Fusion Technology A´

Learning Outcomes
The students have acquired the necessary understanding in order to design and size facilities for tritium operation. They understand the process steps in the tritium plant of a fusion reactor for tritium removal and tritium recovery from tritiated exhaust gas. Furthermore, the students have understood the fundamentals of vacuum physics and are able to design and choose vacuum pumps properly.

Content
Introduction
Tritium Handling
Tritium Plant Technologies
Tritium and Breeding
Fundamentals of Vacuum Science and Technology
Fusion Vacuum systems
Matter Injection into the Plasma Chamber
Fuel Cycle of ITER and DEMO

Media
Presentation slides via ILIAS

Course: Combustion diagnositics [2167048]

Coordinators: R. Schießl, U. Maas
Part of the modules: SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter / Summer Term	de

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
None

Learning Outcomes
After completing this course students can:

- understand the specific requirements for diagnostic techniques in combustion applications.
- explain the physical fundamentals of diagnostic techniques, in particular of laser diagnostics.
- assess the potentials and the limits of the different diagnositc methods.

Content
Diagnostical methods: Laser induced fluorescence, Rayleigh-scattering, Raman-scattering
Chemoluminescence.
Reduced description of combustion processes and measurements.
Discussion of the potential and limits of specific strategies in different combustion systems.

Literature
Lecture notes
A.C. Eckbreth, Laser Diagnostics for Combustion Temperature and Species,
Abacus Press, 2nd ed. (1996)
W. Demtröder, Laser Spectroscopy: Basic Concepts and Instrumentation,
Springer, 3rd ed., 2003
Hollas J.M. Modern Spectroscopy, Wiley, 3rd ed., 1996
K. Kohse-Höinghaus, J. B. Jeffries (ed.), Applied Combustion Diagnostics,
Taylor and Francis
Atkins P., Paula, J., Physical Chemistry, 8th ed., Oxford University Press,
2006

Course: Combustion Engines I [2133113]

Coordinators: H. Kubach, T. Koch

Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Winter term	de

Learning Control / Examinations
oral examination, Duration: 25 min., no auxiliary means

Conditions
None.

Recommendations
None.

Learning Outcomes
The student can name and explain the working princile of combustion engines. He is able to analyse and evaluate the combustion process. He is able to evaluate influences of gas exchange, mixture formation, fuels and exhaust gas aftertreatment on the combustion performance. He can solve basic research problems in the field of engine development.

Content
Introduction, History, Concepts
Working Principle and Applications
Characteristic Parameters
Engine Parts
Crank Drive
Fuels
Gasoline Operation Modes
Diesel Operation Modes
Boosting and Air Management

Media
Slides, Script

Course: Combustion Engines II [2134151]

Coordinators: H. Kubach, T. Koch
Part of the modules: SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Summer term	de

Learning Control / Examinations
oral examination, duration: 25 minutes, no auxiliary means

Conditions
None.

Recommendations
Fundamentals of Combustion Engines I helpful

Learning Outcomes
The students deepen and complement their knowledgement from the lecture combustion engines A. they can name and explain construction elements, development tools and latest development trends. They are be able to analyse and evaluate powertrain concepts which are subject of the lecture.

Content
Engine Maps
Emissions
Exhaust Gas Aftertreatment
Transient Engine Operation
Air Management
ECU Calibration
Electrification and Alternative Powertrain Concepts

Media
Slides, Script

Course: Behaviour Generation for Vehicles [2138336]

Coordinators: C. Stiller, M. Werling

Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 22: Cognitive Technical Systems (p. 423)[SP_22_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], SP 18: Information Technology (p. 419)[SP_18_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 40: Robotics (p. 445)[SP_40_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach], SP 34: Mobile Machines (p. 441)[SP_34_mach], SP 44: Technical Logistics (p. 450)[SP_44_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
written examination

Conditions
none

Recommendations
Fundamentals in measurement, system and control theory, e.g. from the lecture “Measurement and Control Systems”

Learning Outcomes
Modern vehicle control systems like ABS or ESP transform the intention of the driver into a corresponding behaviour of the vehicle. This is achieved by compensating disturbances like a varying traction for example. Within the recent years, vehicles have been increasingly equipped with sensors that gather information about the environment (Radar, Lidar and Video for example). This enables the vehicles to generate an ’intelligent’ behaviour and transform this behaviour into control signals for actors. Several so called ’driver assistance systems’ have already achieved remarkable improvements as far as comfort, safety and efficiency are concerned. But nevertheless, several decades of research will be required to achieve an automated behaviour with a performance equivalent to a human operator (’the driver’). The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Information technology, control theory and kinematic aspects are treated to provide a broad overview over vehicle guidance. Application examples from cutting-edge and future driver assistance systems illustrate the discussed subjects.

Content
1. Driver assistance systems
2. Driving comfort and safety
3. Vehicle dynamics
4. Path and trajectory planning
5. Path control
6. Collision avoidance

Literature
TBA

Course: Failure of Structural Materials: Fatigue and Creep [2181715]

Coordinators: P. Gruber, P. Gumbsch, O. Kraft
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral exam ca. 30 minutes
no tools or reference materials

Conditions
none

Recommendations
preliminary knowlegde in mathematics, mechanics and materials science

Learning Outcomes
The student

- has the basic understanding of mechanical processes to explain the relationships between externally applied load and materials strength.
- can describe the main empirical materials models for fatigue and creep and can apply them.
- has the physical understanding to describe and explain phenomena of failure.
- can use statistical approaches for reliability predictions.
- can use its acquired skills, to select and develop materials for specific applications.

Content
1 Fatigue
1.1 Introduction
1.2 Statistical Aspects
1.3 Lifetime
1.4 Fatigue Mechanisms
1.5 Material Selection
1.6 Thermomechanical Loading
1.7 Notches and Shape Optimization
1.8 Case Study: ICE-Desaster

2 Creep
2.1 Introduction
2.2 High Temperature Plasticity
2.3 Phänomenological DEsciption of Creep
2.4 Creep Mechanisms
2.5 Alloying Effects

Literature

- Engineering Materials, M. Ashby and D.R. Jones (2nd Edition, Butterworth-Heinemann, Oxford, 1998); worth reading, relatively simple but comprehensive
- Mechanical Behavior of Materials, Thomas H. Courtney (2nd Edition, McGraw Hill, Singapur); classic on the mechanical behavior of materials, extensive and good

- Bruchvorgänge in metallischen Werkstoffen, D. Aurich (Werkstofftechnische Verlagsgesellschaft Karlsruhe), relatively simple but yet comprehensive overview of metallic materials
- Fatigue of Materials, Subra Suresh (2nd Edition, Cambridge University Press); standard work on fatigue, all classes of materials, extensive, for beginners and advanced student

Course: Failure of structural materials: deformation and fracture [2181711]

Coordinators: P. Gumbsch, D. Weygand, O. Kraft
Part of the modules: SP 02: Powertrain Systems (p. 407)[SP_02_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach], SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach], SP 43: Technical Ceramics and Powder Materials (p. 449)[SP_43_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Winter term	de

Learning Control / Examinations
oral exam ca. 30 minutes
no tools or reference materials

Conditions
none

Recommendations
preliminary knowlegde in mathematics, mechanics and materials science

Learning Outcomes
The student

- has the basic understanding of mechanical processes to explain the relationship between externally applied load and materials strength.
- can explain the foundation of linear elastic fracture mechanics and is able to determine if this concept can be applied to a failure by fracture.
- can decribe the main empirical materials models for deformation and fracture and can apply them.
- has the physical understanding to describe and explain phenomena of failure.

Content

1. Introduction
2. linear elasticity
3. classification of stresses
4. Failure due to plasticity
   - tensile test
   - dislocations
   - hardening mechanisms
   - guidelines for dimensioning
5. composite materials
6. fracture mechanics
   - hypotheses for failure
   - linear elasic fracture mechanics
   - crack resitance
   - experimental measurement of fracture toughness
   - defect measurement
   - crack propagation

- application of fracture mechanics
- atomistics of fracture

Exercises are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students.

Literature

- Engineering Materials, M. Ashby and D.R. Jones (2nd Edition, Butterworth-Heinemann, Oxford, 1998); worth reading, relatively simple but comprehensive
- Mechanical Behavior of Materials, Thomas H. Courtney (2nd Edition, McGraw Hill, Singapur); classic on the mechanical behavior of materials, extensive and good
- Bruchvorgänge in metallischen Werkstoffen, D. Aurich (Werkstofftechnische Verlagsgesellschaft Karlsruhe), relatively simple but yet comprehensive overview of metallic materials

Course: Gear Cutting Technology [2149655]

Coordinators: M. Klaiber
Part of the modules: SP 39: Production Technology (p. 443)[SP_39_mach], SP 12: Automotive Technology (p. 415)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
The assessment is carried out as an oral examination. The examination is offered every winter semester in agreement with the Lecturer.

Conditions
None

Recommendations
None

Learning Outcomes
The students ...

- can describe the basic terms of gearings and are able to explain the imparted basics of the gearwheel and gearing theory.
- are able to specify the different manufacturing processes and machine technologies for producing gearings. Furthermore they are able to explain the functional principles and the dis-/advantages of these manufacturing processes.
- can apply the basics of the gearing theory and manufacturing processes on new problems.
- are able to read and interpret measuring records for gearings.
- are able to make an appropriate selection of a process based on a given application
- can describe the entire process chain for the production of toothed components and their respective influence on the resulting workpiece properties.

Content
Based on the gearing theory, manufacturing processes and machine technologies for producing gearings, the needs of modern gear manufacturing will be discussed in the lecture. For this purpose, various processes for various gear types are taught which represent the state of the art in practice today. A classification in soft and hard machining and furthermore in cutting and non-cutting technologies will be made. For comprehensive understanding the processes, machine technologies, tools and applications of the manufacturing of gearings will be introduced and the current developments presented. For assessment and classification of the applications and the performance of the technologies, the methods of mass production and manufacturing defects will be discussed. Sample parts, reports from current developments in the field of research and an excursion to a gear manufacturing company round out the lecture.
The following topics will be covered:

- Sample applications
- Basics of gearing geometry
- Need of gearboxes
- Soft machining processes
- Hardening processes
- Hard machining processes
- Bevel gear production

- Measurement and testing
- Manufacturing of gearbox components
- Special gearings

Media
Lecture slides will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Slides

Remarks
None

Course: Virtual Engineering I [2121352]

Coordinators: J. Ovtcharova
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	4	Winter term	en

Learning Control / Examinations
Writen examination 90 min. Masterstudents of Mechanical Engineering with "SP 28 Lifecycle Engineering" take an oral examination of 20 min of this core subject.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students can:

- rename and explain the basic methods of virtual engineering and the typical problems in product development.
- associate the methods and problems of the corresponding phases of the product life cycle and derive the necessary interfaces.
- select the appropriate IT systems for given problems and evaluate their suitability for the support of management's approach PLM.
- apply CAD/CAx/PLM-Systems using simple exercises.

Content
The lecture presents the informational interrelationship required for understanding the virtual product development process. For this purpose, an emphasis and focus will be placed on IT-systems used in the industrial sector as support for the process chain of virtual engineering:

- Product Lifecycle Management refers to the entire lifecycle of the product, beginning with the concept phase up through disassembling and recycling.
- CAx-systems for the virtual product development allow the modeling of a digital product in regards to design, construction, manufacturing and maintenance.
- Validation Systems allow the checking of the product in regard to static, dynamics, safety and build ability.

The goal of the lecture is to clarify the relationship between construction and validation operations through the usage of virtual prototypes and VR/AR/MR visualisation techniques in connection with PDM/PLM-systems. This will be achieved through an introduction to each particular system along with praxis-oriented exercises.

Literature
Lecture slides

Course: Virtual Engineering II [2122378]

Coordinators: J. Ovtcharova
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Summer term	en

Learning Control / Examinations
Writen examination 90 min. Masterstudents of Mechanical Engineering with "SP 28 Lifecycle Engineering" take an oral examination of 20 min of this core subject.

Conditions
None.

Recommendations
None.

Learning Outcomes
The students will be able to:

- describe virtual reality, how the stereoscopic effect occurs and compare the technologies to simulate this effect.
- describe how to model a scene in VR, store the VR graph on a computer and explain the inner workings of the VR pipeline for visualizing the scene.
- name various systems for interacting with the VR scene and assess the advantages and disadvantages of various manipulation and tracking devices.
- compare validation tests that can be carried through in the product development process with the aid of a virtual mock-up (VMU) and describe the difference between a VMU, a physical mock-up (PMU) and a virtual prototype (VP).
- point out the vision of an integrated virtual product development and which challenges need to be resolved towards that vision.

Content
The lecture presents the informational interrelationship required for understanding the virtual product development process. For this purpose, an emphasis and focus will be placed on IT-systems used in the industrial sector as support for the process chain of virtual engineering:

- The corresponding models can be visualized in Virtual Reality Systems, from single parts up through a complete assembly.
- Virtual Prototypes combine CAD-data as well as information about the remaining characteristics of the components and assembly groups for immersive visualisation, functionality tests and functional validations in the VR/AR/MR environment.
- Integrated Virtual Product Development explains exemplified the product development process from the point of view of Virtual Engineering.

The goal of the lecture is to clarify the relationship between construction and validation operations through the usage of virtual prototypes and VR/AR/MR visualisation techniques in connection with PDM/PLM-systems. This will be achieved through an introduction to each particular IT-system along with praxis-oriented exercises.

Literature
Lecture slides

Course: Virtual Engineering Lab [2123350]

Coordinators: J. Ovtcharova
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Winter / Summer Term	de

Learning Control / Examinations
Assessment of another type (graded), procedure see webpage.

Conditions
None.

Recommendations
Participation in the course Virtual Engineering 2 [2122378]

Learning Outcomes
The students are able to:

- operate and use hardware and software for Virtual Reality applications.
- Students can design solutions for a complex task with scientific methods and implement the solution in teamwork, with best available technology.
- Students can determine the solution quality of partial steps by means of monitoring methods.
- solve subtasks within a specific work package in small groups, keeping the interfaces to other work packages in mind and merge this solution in the final product.

Content
The course consists of following three overlapping parts:
• Basics: Introduction in Virtual Reality (hardware, software, applications)
• Tool Kit: Exercises in the task specific software systems
• Application: autonomous project work in the area of Virtual Reality in small groups

Media
Stereoscopic projection in MR and VR at the Lifecycle Engineering Solutions Center (LESC), 15 computers, beamer

Literature
Presentations, Exercise documents, Tutorials, Books for individual work

Remarks
Number of participants limited. There is a participant selection process.

Course: Virtual Reality Laboratory [2123375]

Coordinators: J. Ovtcharova
Part of the modules: SP 40: Robotics (p. 445)[SP_40_mach], SP 04: Automation Technology (p. 409)[SP_04_mach], SP 31: Mechatronics (p. 435)[SP_31_mach], SP 27: Modeling and Simulation in Energy- and Fluid Engineering (p. 431)[SP_27_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Winter / Summer Term	de

Learning Control / Examinations
Assessment of another type (graded), procedure see webpage.

Conditions
None

Recommendations
Participation in the course Virtual Engineering 2 [2122378]

Learning Outcomes
The students are able to operate and use hardware and software for Virtual Reality applications in order to:

- design solutions for complex tasks in a team.
- solve subtasks within a specific work package in small groups, keeping the interfaces to other work packages in mind and
- merge this solution in the final product.

Content
The Virtual Reality lab course consists of following three overlapping parts:

- Basics: Introduction in Virtual Reality (hardware, software, applications)
- Tool Kit: Exercises in the task specific software systems
- Application: autonomous project work in the area of Virtual Reality in small groups

Soft Skills: Methodical approach to practical engineering problems, team and interdisciplinary work, time management.

Media
Stereoscopic projection in MR and VR at the Lifecycle Engineering Solutions Center (LESC), 15 computers, beamer

Literature
Presentations, Exercise documents, Tutorials, Books for individual work

Course: Virtual training factory 4.X [2123351]

Coordinators: J. Ovtcharova
Part of the modules: SP 28: Lifecycle Engineering (p. 432)[SP_28_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	3	Winter / Summer Term	de

Learning Control / Examinations
Assessment of another type (graded), procedure see webpage.

Conditions
None.

Learning Outcomes
Students are able to:

- Support the product development and production planning using virtual reality concepts and IT tools.
- Describe the requirements of the use of virtual reality in the product development process in interdisciplinary teams.
- Use the knowledge gained from virtual validation methods on the product development process and carry out optimizations in production planning.

Content
The learning factory enables students to experience the product development process, from product concept to production, as in a startup. Theoretical introduction and exercises in VR (hardware, software, applications). Independent project work in the area of virtual reality, especially for virtual product development and production planning.

Media
Stereoscopic projection in MR and VR at the Lifecycle Engineering Solutions Center (LESC), 15 computers, beamer

Literature
Presentations, Exercise documents, Tutorials, Books for individual work.

Course: Heatpumps [2166534]

Coordinators: H. Wirbser, U. Maas
Part of the modules: SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach], SP 45: Engineering Thermodynamics (p. 451)[SP_45_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
Oral
Duration: 30 min.

Conditions
None

Recommendations
None

Learning Outcomes
The attendance of this course enables students to:

- describe the setup and the working principle of heat pumps.
- specify the various types of heat pumps.
- analyse the energetic requirements.
- asses the advantages and drawbacks of heat pumps as heating system.

Content
The aim of this lecture is to promote heat pumps as heating systems for small an medium scale facilities and to discuss their advantages as well as their drawbacks. After considering the actual energy situation and the political requirements the different aspects of heat pumps are elucidated. The requirements concerning heat sources, the different components and the various types of heat pumps are discussed. In addition ecological and economical aspects are taken into consideration. The coupling of heat pumps with heat accumulators in heating systems will also be part of the lecture.

Literature
Vorlesungsunterlagen
Bach, K.: Wärmepumpen, Bd. 26 Kontakt und Studium, Lexika Verlag, 1979
Kirn, H., Hadenfeldt, H.: Wärmepumpen, Bd. 1: Einführung und Grundlagen, Verlag C. F. Müller, 1987
von Cube, H.L.: Lehrbuch der Kältetechnik, Verlag C.F. Müller, Karlsruhe, 1975.
von Cube, H.L., Steimle,F.: Wärmepumpen, Grunglagen und Praxis VDI-Verlag, Düsseldorf, 1978.

Course: Hydrogen Technologies [2170495]

Coordinators: T. Jordan
Part of the modules: SP 23: Power Plant Technology (p. 424)[SP_23_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
oral
Duration: approximately 30 minutes

Auxiliary:no tools or reference materials may be used during the exam

Conditions
None.

Learning Outcomes
The course content is the cross-cutting issue of hydrogen as energy carrier. After successful participation the students may reflect on the fundamental technological basis of an energy system using predominantly hydrogen as an energy carrier or energy storage. Based on this knowledge they may objectify the principle idea of an hydrogen economy.
The students know the fundamental physical and chemical properties of hydrogen and may apply their knowledge on thermodynamics to compare efficiencies of different solutions with hydrogen. They can list, compare and evaluate established and future solutions for production, storage and distribution of hydrogen. They can explain advantages and disadvantages of using hydrogen in conventional combustion processes versus using hydrogen in different fuel cells. In particular the can describe the specific safety aspects related to hydrogen, compare them with other energy vectors and evaluate different measures for risk mitigation.

Content
Basic concepts
Production
Transport and storage
Application
Safety aspects

Literature
Ullmann's Encyclopedia of Industrial Chemistry
Hydrogen and Fuel Cells, Ed. S. Stolten, Wiley-VCH, 2010, ISBN 978-3-527-32711-9

Course: Wave Propagation [2161219]

Coordinators: W. Seemann
Part of the modules: SP 04: Automation Technology (p. 409)[SP_04_mach], SP 11: Vehicle Dynamics, Vehicle Comfort and Acoustics (p. 414)[SP_11_mach], (p. 465)[SP_60_mach], SP 01: Advanced Mechatronics (p. 405)[SP_01_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
Oral

30 minutes (optional subject), 20 minutes (major subject)

no means

Conditions
Vibration theory

Learning Outcomes
The course gives an introduction into wave propagation phenomena. This contains both one-dimensional continua (beams, rods, strings) as well as two- and three-dimensional continua. Initial condition problems are treated. Fundamental effects like phase velocity, group velocity or dispersion are explained. Wave propagation is used to show the limits of structural models like beams. In addition surface waves and acoustic waves are covered.

Content
Wave propagation in strings and rods, d'Alembert's solution, initial value problem, boundary conditions, excitation at the boundary, energy transport, wave propagation in beams, Bernoulli-Euler beams, group velocity, beams with changing cross-section, reflexion and transmission, Timoshenko beam theory, wave propagation in membranes and plates, acoustic waves, reflexion and refraction, spherical waves, s- and p-waves in elastic media, reflexion and transmission at bounding surfaces, surface waves

Literature
P. Hagedorn and A. Dasgupta: Vibration and waves in continuous mechanical systems. Wiley, 2007.

Course: Materials Characterization [2174586]

Coordinators: J. Gibmeier
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

ECTS Credits	Hours per week	Term	Instruction language
7	3	Winter term	de

Learning Control / Examinations
The assessment consists of a certificate and an oral exam (about 25 minutes).
Successful participation 8attendance) in the exercises (lab exercises) for Materials Characterization is obligatory for admission for the oral exam on Materials Characterization.

Conditions
Successful participation (attendance) in the exercises (lab exercises) for Materials Characterization is obligatory for admission for the oral exam on Materials Characterization.

Learning Outcomes
The students have fundamental knowledge about methods of material analysis. They have a basic understanding to transfer this fundamental knowledge on problems in engineering science. Furthermore, the students have the ability to describe technical material by its microscopic and submicroscopic structure.

Content
The following methods will be introduced within this module:

- microscopic methods: optical microscopy, electron microscopy (SEM/TEM), atomic force microscopy
- material and microstructure analyses by means of X-ray, neutron and electron beams
- analysis methods at SEM/TEM (e.g. EELS)
- spectroscopic methods (e.g. EDS / WDS)

Literature
lecture notes (will be provided at the beginning of the lecture)

literature will be quoted at the beginning of the lecture

Course: Materials for Lightweight Construction [2174574]

Coordinators: K. Weidenmann
Part of the modules: SP 25: Lightweight Construction (p. 427)[SP_25_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
Oral exam, about 25 minutes

Conditions
none

Recommendations
Werkstoffkunde I/II

Learning Outcomes
The students are able to describe the mechanisms of strength and stiffness that fundamentally act in different lightweight materials and to explain the underlying material science aspects against the background of lightweight materials design.

Content
Introduction
Constructive, production-orientied and material aspects of lightweight construction
Aluminium-based alloys
Aluminium wrought alloys
Aluminium cast alloys
Magnesium-based alloys
Magnesium wrought alloys
Magnesium cast alloys
Titanium-based alloys
Titanium wrought alloys
Titanium cast alloys
High-strength steels
High-strength structural steels,
Heat-treatable steels, press-hardening and hardenable steels
Composites - mainly PMC
Matrices
Reinforcements
Basic mechanical principles of composites
Hybrid composites
Special materials for lightweight design
Beryllium alloys
Metallic Glasses
Applications

Literature
Presentation slides and additional lecture notes are handed out during the lecture, additional literature recommendations given

Course: Materials Science and Engineering III [2173553]

Coordinators: M. Heilmaier, K. Lang
Part of the modules: SP 26: Materials Science and Engineering (p. 429)[SP_26_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	5	Winter term	de

Learning Control / Examinations
Oral exam, about 35 minutes

Conditions
Basic knowledge in materials science and engineering (Werkstoffkunde I/II)

Learning Outcomes
The students are familiar with thermodynamic and kinetics of phase transformations in the solid state (nucleation and growth phenomena), the mechanisms of microstructure formation and their consequences on microstructure-property relationships. The students can apply these concepts to metallic materials. They can assess the effects of heat treatments and of alloying on the microstructure and the properties of iron-based materials (steels in particular). Further, the students are able to select and heat treat appropriate steels for structural applications in the field of mechanical engineering.

Content
Properties of pure iron; basic thermodynamic principals of single-component and of binary systems; nucleation and growth; diffusion processes in crystalline iron; the phase diagram Fe-Fe_3C; impact of alloying on properties of Fe-C-alloys; non-equilibrium phases of iron; multicomponent iron-based alloys; heat treatment technology; hardening and annealing of steals.

Literature
Lecture Notes; Problem Sheets; Bhadeshia, H.K.D.H. & Honeycombe, R.W.K.
Steels – Microstructure and Properties
CIMA Publishing, 3. Auflage, 2006

Course: Materials modelling: dislocation based plasticy [2182740]

Coordinators: D. Weygand
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach], SP 26: Materials Science and Engineering (p. 429)[SP_26_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Summer term	de

Learning Control / Examinations
oral exam ca. 30 minutes

Conditions
none

Recommendations
preliminary knowlegde in mathematics, physics and materials science

Learning Outcomes
The student

- has the basic understanding of the physical basics to describe dislocations and their interaction with point, line and area defects.
- can apply modelling approaches for dislocation based plasticity.
- can explain discrete methods for modelling of microstructural evolution processes.

Content
1. Introduction
2. elastic fields of dislocations
3. slip, crystallography
4. equations of motion of dislocations
a) fcc
b) bcc
5. interaction between dislocations
6. molecular dynamics
7. discrete dislocation dynamics
8. continuum description of dislocations

Literature

1. D. Hull and D.J. Bacon, Introduction to Dislocations, Oxford Pergamon 1994
2. W. Cai and W. Nix, Imperfections in Crystalline Solids, Cambridge University Press, 2016
3. J.P. Hirth and J. Lothe: Theory of dislocations, New York Wiley 1982. (oder 1968)
4. J. Friedel, Dislocations, Pergamon Oxford 1964.
5. V. Bulatov, W. Cai, Computer Simulations of Dislocations, Oxford University Press 2006
6. A.S. Argon, Strengthening mechanisms in crystal plasticity, Oxford materials.

Course: Machine Tools and Industrial Handling [2149902]

Coordinators: J. Fleischer
Part of the modules: SP 10: Engineering Design (p. 412)[SP_10_mach], SP 39: Production Technology (p. 443)[SP_39_mach], SP 04: Automation Technology (p. 409)[SP_04_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	6	Winter term	de

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students ...

- are able to assess the use and application of machine tools and handling equipment and to differentiate between them in terms of their characteristics and design,
- can describe and discuss the essential elements of the machine tool (frame, main spindle, feed axes, peripheral equipment, control unit),
- are able to select and dimension the essential components of a machine tool,
- are capable of selecting and evaluating machine tools according to technical and economic criteria.

Content
The lecture gives an overview of the construction, use and application of machine tools and industrial handling equipment. In the course of the lecture a well-founded and practice-oriented knowledge for the selection, design and evaluation of machine tools is conveyed. First, the main components of the machine tools are systematically explained and their design principles as well as the integral machine tool design are discussed. Subsequently, the use and application of machine tools will be demonstrated using typical machine examples. Based on examples from current research and industrial applications, the latest developments are discussed, especially concerning the implementation of Industry 4.0.
The individual topics are:

- Frames and frame components
- Feed axes
- Spindles
- Peripheral equipment
- Control unit
- Metrological evaluation and machine testing
- Process monitoring
- Maintenance of machine tools
- Safety assessment of machine tools
- Machine examples

Media
Lecture notes will be provided in ilias (https://ilias.studium.kit.edu/).

Literature
Lecture Notes

Remarks
None

Course: Windpower [2157381]

Coordinators: N. Lewald

Part of the modules: SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 15: Fundamentals of Energy Technology (p. 417)[SP_15_mach], SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 55: Energy Technology for Buildings (p. 460)[SP_55_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations

The assessment consists of an oral exam (20 min) taking place at the beginning of the recess period (according to Section 4 (2), 2 of the examination regulation). The exam takes place in every winter semester. Re-examinations are offered at every ordinary examination date.

Conditions

None.

Learning Outcomes

The goal is to relay basic fundamentals for the use of wind power.
Wind Power fundamental lecture. Focus of the lecture is basic knowledge for the use of wind power for electricity, complemented by historical development, basic knowledge on wind systems and alternative renewable energies.

Content

The lecture contacts due to the broadly basic knowledge to all listeners of all terms.
On the basis of an overview of alternative, renewable energy technologies as well as general energy data, the entrance is transacted into the wind energy by means of an overview of the historical development of the wind force.
Since the wind supplies the driving power as indirect solar energy, the global and the local wind systems as well as their
measurement and energy content are dedicated to its own chapter.
Whereupon constructing the aerodynamic bases and connections of wind-power plants and/or their profiles are described. The electrical system of the wind-power plants forms a further emphasis. Begun of fundamental generator technology over control and controlling of the energy transfer.
After the emphasis aerodynamics and electrical system the further components of wind-power plants and their characteristics in the connection are described.
Finally the current economic, ecological and legislations boundary conditions for operating wind-power plants are examined.
In addition to wind-power plants for electricity production, the lecture is also shortly aiming at alternative use possibilities such as pumping systems.
Finally an overview of current developments like super-grids and visions of the future of the wind power utilization will be
given.

Media

A scriptum that has to be overhault is available under www.ieh.kit.edu under “Studium und Lehre”. Further book titles or relevant websites will be announced in the lecture.

Course: Vortex Dynamics [2153438]

Coordinators: J. Kriegseis
Part of the modules: SP 24: Energy Converting Engines (p. 426)[SP_24_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 46: Thermal Turbomachines (p. 452)[SP_46_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral;

Duration: 30 minutes

no auxiliary means

Conditions
none

Learning Outcomes
The students can describe the physical basics and the mathematical description of vortex flows and are able to explaincharacteristic phenomena of vortex flows (e.g. vorticity, circulation and dissipation). They are qualified to analyze two- and three-dimensional vortex flows in steady and time-dependent form with respect to their structure and time-behaviour.

Content

- Definition of a vortex
- Theoretical description of vortex flow
- Steady and time-dependent solutions of vortex flows
- Helmholtz's vortex theorems
- Vorticity equation
- Properties of various vortical structures
- Introduction of various vortex identification approaches

Media
chalk board, Powerpoint, document camera

Literature
Spurk, J.H.: Fluid Mechanics, Springer, 1996
Green, S.I.: Fluid Vortices, Kluwer Academic Publishers, 1995
Wu, J.-Z. et al.: Vorticity and Vortex Dynamics, Springer, 2006
Saffman, P.G.: Vortex Dynamics, Cambrigde University Press, 1992

Course: Scientific computing for Engineers [2181738]

Coordinators: D. Weygand, P. Gumbsch
Part of the modules: SP 30: Applied Mechanics (p. 434)[SP_30_mach], SP 49: Reliability in Mechanical Engineering (p. 454)[SP_49_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
Written exam (90 minutes)

Conditions
The lecture can not be combined with the lecture “Application of advanced programming languages in mechanical engineering” (2182735).

Learning Outcomes
The student can

- apply the programming language C^{++} for scientific computing in the field of materials science
- adapt programs for use on parallel platforms
- choose suitable numerical methods for the solution of differential equations.
- write scripts controlling simulations
- write script for data handling

Through the accompanying exercises the students are able to apply the content of the lecture.

Content
1. Introduction: why scientific computing
2. computer architectures
3. Introduction to Unix/Linux
4. Foundations of C++11

- progamm organization
- data types, operator, control structures
- dynamic memory allocation
- functions
- class
- OpenMP parallelization
- C++11 standard

5. numeric /algorithms

- finite differences
- MD simulations: 2nd order differential equations
- algorithms for particle simulations
- solver for linear systems of eqns.

6. Scripts

- basics bash scripts

- python for data analysis

Exercises (2181739, 2 SWS) are used for complementing and deepening the contents of the lecture as well as for answering more extensive questions raised by the students and for testing progress in learning of the topics.

Media
Slides of lectures and execises.

Literature
programming language C++

1. C++: Einführung und professionelle Programmierung; U. Breymann, Hanser Verlag München
2. C++ and object-oriented numeric computing for Scientists and Engineers, Daoqui Yang, Springer Verlag.
3. The C++ Programming Language, Bjarne Stroustrup, Addison-Wesley
4. Die C++ Standardbibliothek, S. Kuhlins und M. Schader, Springer Verlag

numerical analysis

1. Numerical recipes in C++ / C / Fortran (90), Cambridge University Press
2. Numerische Mathematik, H.R. Schwarz, Teubner Stuttgart
3. Numerische Simulation in der Moleküldynamik, Griebel, Knapek, Zumbusch, Caglar, Springer Verlag

Course: Ignition systems [2133125]

Coordinators: O. Toedter
Part of the modules: SP 01: Advanced Mechatronics (p. 405)[SP_01_mach], SP 58: Combustion engines based powertrains (p. 462)[SP_58_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral exam 20 minutes

Conditions
None.

Learning Outcomes
The Student can name the ignition systems and describe the ignition processes. He can explain the interaction between ignition and combustion process.

Content

- Ignition process
- Spark ignition
- Spark ignition system design
- Limits of spark ignition
- New developments of spark ignition systems
- New and alternative spark systems

Course: Two-Phase Flow and Heat Transfer [2169470]

Coordinators: T. Schulenberg, M. Wörner
Part of the modules: SP 53: Fusion Technology (p. 458)[SP_53_mach], SP 41: Fluid Dynamics (p. 447)[SP_41_mach], SP 23: Power Plant Technology (p. 424)[SP_23_mach], SP 21: Nuclear Energy (p. 422)[SP_21_mach]

ECTS Credits	Hours per week	Term	Instruction language
4	2	Winter term	de

Learning Control / Examinations
oral
Duration: approximately 30 minutes

no tools or reference materials may be used during the exam

Conditions
None.

Recommendations
Basics of fluid mechanics and thermodynamics are a mandatory requirement.

Learning Outcomes
The students can describe two-phase flows with heat transfer as phenomena occuring in steam generators and condensers (e.g. in power stations or refrigerators). They can distinguish different flow regimes and transitions and apply two-phase flow models. The students are qualified to explain the characteristics of different flow examples (e.g. pressure drop of two phase flows, pool boiling, forced convective boiling, condensation) and can analysze two-phase flow instabilities.

Content

- Examples for technical applications
- Definitions and averaging of two-phase flows
- Flow regimes and transitions
- Two-phase models
- Pressure drop of two phase flows
- Pool boiling
- Forced convective boiling
- Condensation
- Two-phase flow instabilities

Media
Power Point presentations
Excel analyses

Literature
lecture notes

Karlsruher Institut für Technologie

Universität des Landes Baden-Württemberg und
nationales Forschungszentrum in der Helmholtz-Gemeinschaft

Amtliche Bekanntmachung

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Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Masterstudiengang Maschinenbau

vom 04. August 2015

Aufgrund von § 10 Absatz 2 Ziff. 5 und § 20 des Gesetzes über das Karlsruher Institut für Technologie (KIT-Gesetz - KITG) in der Fassung vom 14. Juli 2009 (GBl. S. 317 f), zuletzt geändert durch Artikel 5 des Dritten Gesetzes zur Änderung hochschulrechtlicher Vorschriften (3. Hochschulrechtsänderungsgesetz – 3. HRÄG) vom 01. April 2014 (GBl. S. 99, 167) und § 8 Absatz 5 des Gesetzes über die Hochschulen in Baden-Württemberg (Landeshochschulgesetz - LHG) in der Fassung vom 1. Januar 2005 (GBl. S. 1 f), zuletzt geändert durch Artikel 1 des 3. HRÄG vom 01. April 2014 (GBl. S. 99 ff.), hat der Senat des KIT am 20. Juli 2015 die folgende Studien- und Prüfungsordnung für den Masterstudiengang Maschinenbau beschlossen.

Der Präsident hat seine Zustimmung gemäß § 20 Absatz 2 KITG iVm. § 32 Absatz 3 Satz 1 LHG am 04. August 2015 erteilt.

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Präambel

Das KIT hat sich im Rahmen der Umsetzung des Bolognaprozesses zum Aufbau eines Europäischen Hochschulraumes zum Ziel gesetzt, dass am Abschluss des Studiums am KIT der Mastergrad stehen soll. Das KIT sieht daher die am KIT angebotenen konsekutiven Bachelor- und Masterstudiengänge als Gesamtkonzept mit konsekutivem Curriculum.

I. Allgemeine Bestimmungen

§ 1 Geltungsbereich

Diese Masterprüfungsordnung regelt Studienablauf, Prüfungen und den Abschluss des Studiums im Masterstudiengang Maschinenbau am KIT.

§ 2 Ziel des Studiums, Akademischer Grad

(1) Im konsekutiven Masterstudium sollen die im Bachelorstudium erworbenen wissenschaftlichen Qualifikationen weiter vertieft, verbreitert, erweitert oder ergänzt werden. Ziel des Studiums ist die Fähigkeit, die wissenschaftlichen Erkenntnisse und Methoden selbstständig anzuwenden und ihre Bedeutung und Reichweite für die Lösung komplexer wissenschaftlicher und gesellschaftlicher Problemstellungen zu bewerten.

(2) Aufgrund der bestandenen Masterprüfung wird der akademische Grad „Master of Science (M.Sc.)“ für den Masterstudiengang Maschinenbau verliehen.

§ 3 Regelstudienzeit, Studienaufbau, Leistungspunkte

(1) Die Regelstudienzeit beträgt vier Semester.

(2) Das Lehrangebot des Studiengangs ist in Fächer, die Fächer sind in Module, die jeweiligen Module in Lehrveranstaltungen gegliedert. Die Fächer und ihr Umfang werden in § 19 festgelegt. Näheres beschreibt das Modulhandbuch.

(3) Der für das Absolvieren von Lehrveranstaltungen und Modulen vorgesehene Arbeitsaufwand wird in Leistungspunkten (LP) ausgewiesen. Die Maßstäbe für die Zuordnung von Leistungspunkten entsprechen dem European Credit Transfer System (ECTS). Ein Leistungspunkt entspricht einem Arbeitsaufwand von etwa 30 Zeitstunden. Die Verteilung der Leistungspunkte auf die Semester hat in der Regel gleichmäßig zu erfolgen.

(4) Der Umfang der für den erfolgreichen Abschluss des Studiums erforderlichen Studien- und Prüfungsleistungen wird in Leistungspunkten gemessen und beträgt insgesamt 120 Leistungspunkte.

(5) Lehrveranstaltungen können nach vorheriger Ankündigung auch in englischer Sprache angeboten werden, sofern es deutschsprachige Wahlmöglichkeiten gibt.

§ 4 Modulprüfungen, Studien- und Prüfungsleistungen

(1) Die Masterprüfung besteht aus Modulprüfungen. Modulprüfungen bestehen aus einer oder mehreren Erfolgskontrollen.

Erfolgskontrollen gliedern sich in Studien- oder Prüfungsleistungen.

(2) Prüfungsleistungen sind:

1. schriftliche Prüfungen,
2. mündliche Prüfungen oder
3. Prüfungsleistungen anderer Art.

(3) Studienleistungen sind schriftliche, mündliche oder praktische Leistungen, die von den Studierenden in der Regel lehrveranstaltungsbegleitend erbracht werden. Die Masterprüfung darf nicht mit einer Studienleistung abgeschlossen werden.

(4) Von den Modulprüfungen sollen mindestens 70 % benotet sein.

(5) Bei sich ergänzenden Inhalten können die Modulprüfungen mehrerer Module durch eine auch modulübergreifende Prüfungsleistung (Absatz 2 Nr.1 bis 3) ersetzt werden.

§ 5 Anmeldung und Zulassung zu den Modulprüfungen und Lehrveranstaltungen

(1) Um an den Modulprüfungen teilnehmen zu können, müssen sich die Studierenden online im Studierendenportal zu den jeweiligen Erfolgskontrollen anmelden. In Ausnahmefällen kann eine Anmeldung schriftlich im Studierendenservice oder in einer anderen vom Studierendenservice autorisierten Einrichtung erfolgen. Für die Erfolgskontrollen können durch die Prüfenden Anmeldefristen festgelegt werden. Die Anmeldung der Masterarbeit ist im Modulhandbuch geregelt.

(2) Sofern Wahlmöglichkeiten bestehen, müssen Studierende, um zu einer Prüfung in einem bestimmten Modul zugelassen zu werden, vor der ersten Prüfung in diesem Modul mit der Anmeldung zu der Prüfung eine bindende Erklärung über die Wahl des betreffenden Moduls und dessen Zuordnung zu einem Fach abgeben. Auf Antrag des/der Studierenden an den Prüfungsausschuss kann die Wahl oder die Zuordnung nachträglich geändert werden. Sofern bereits ein Prüfungsverfahren in einem Modul begonnen wurde, ist die Änderung der Wahl oder der Zuordnung erst nach Beendigung des Prüfungsverfahrens zulässig; dies gilt nur für Prüfungsleistungen.

(3) Zu einer Erfolgskontrolle ist zuzulassen, wer

1. in den Masterstudiengang Maschinenbau am KIT eingeschrieben ist; die Zulassung beurlaubter Studierender ist auf Prüfungsleistungen beschränkt und

2. nachweist, dass er die im Modulhandbuch für die Zulassung zu einer Erfolgskontrolle festgelegten Voraussetzungen erfüllt und

3. nachweist, dass er in dem Masterstudiengang Maschinenbau den Prüfungsanspruch nicht verloren hat.

(4) Nach Maßgabe von § 30 Abs. 5 LHG kann die Zulassung zu einzelnen Pflichtveranstaltungen beschränkt werden. Der/die Prüfende entscheidet über die Auswahl unter den Studierenden, die sich rechtzeitig bis zu dem von dem/der Prüfenden festgesetzten Termin angemeldet haben unter Berücksichtigung des Studienfortschritts dieser Studierenden und unter Beachtung von § 13 Abs. 1 Satz 1 und 2, sofern ein Abbau des Überhangs durch andere oder zusätzliche Veranstaltungen nicht möglich ist. Für den Fall gleichen Studienfortschritts sind durch die KIT-Fakultäten weitere Kriterien festzulegen. Das Ergebnis wird den Studierenden rechtzeitig bekannt gegeben.

(5) Die Zulassung ist zu versagen, wenn die in Absatz 3 und 4 genannten Voraussetzungen nicht erfüllt sind. Die Zulassung kann versagt werden, wenn die betreffende Erfolgskontrolle bereits in einem grundständigen Bachelorstudiengang am KIT erbracht wurde, der Zulassungsvoraussetzung für diesen Masterstudiengang gewesen ist. Dies gilt nicht für Mastervorzugsleistungen. Zu diesen ist eine Zulassung nach Maßgabe von Satz 1 ausdrücklich zu genehmigen.

§ 6 Durchführung von Erfolgskontrollen

(1) Erfolgskontrollen werden studienbegleitend, in der Regel im Verlauf der Vermittlung der Lehrinhalte der einzelnen Module oder zeitnah danach, durchgeführt.

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(2) Die Art der Erfolgskontrolle (§ 4 Abs. 2 Nr. 1 bis 3, Abs. 3) wird von der/dem Prüfenden der betreffenden Lehrveranstaltung in Bezug auf die Lerninhalte der Lehrveranstaltung und die Lernziele des Moduls festgelegt. Die Art der Erfolgskontrolle, ihre Häufigkeit, Reihenfolge und Gewichtung sowie gegebenenfalls die Bildung der Modulnote müssen mindestens sechs Wochen vor Vorlesungsbeginn im Modulhandbuch bekannt gemacht werden. Im Einvernehmen von Prüfendem und Studierender bzw. Studierendem können die Art der Prüfungsleistung sowie die Prüfungssprache auch nachträglich geändert werden; im ersten Fall ist jedoch § 4 Abs. 4 zu berücksichtigen. Bei der Prüfungsorganisation sind die Belange Studierender mit Behinderung oder chronischer Erkrankung gemäß § 13 Abs. 1 zu berücksichtigen. § 13 Abs. 1 Satz 3 und 4 gelten entsprechend.

(3) Bei unvertretbar hohem Prüfungsaufwand kann eine schriftlich durchzuführende Prüfungsleistung auch mündlich, oder eine mündlich durchzuführende Prüfungsleistung auch schriftlich abgenommen werden. Diese Änderung muss mindestens sechs Wochen vor der Prüfungsleistung bekannt gegeben werden.

(4) Bei Lehrveranstaltungen in englischer Sprache (§ 3 Abs. 6) können die entsprechenden Erfolgskontrollen in dieser Sprache abgenommen werden. § 6 Abs. 2 gilt entsprechend.

(5) *Schriftliche Prüfungen* (§ 4 Abs. 2 Nr. 1) sind in der Regel von einer/einem Prüfenden nach § 18 Abs. 2 oder 3 zu bewerten. Sofern eine Bewertung durch mehrere Prüfende erfolgt, ergibt sich die Note aus dem arithmetischen Mittel der Einzelbewertungen. Entspricht das arithmetische Mittel keiner der in § 7 Abs. 2 Satz 2 definierten Notenstufen, so ist auf die nächstliegende Notenstufe auf- oder abzurunden. Bei gleichem Abstand ist auf die nächstbessere Notenstufe zu runden. Das Bewertungsverfahren soll sechs Wochen nicht überschreiten. Schriftliche Prüfungen dauern mindestens 60 und höchstens 300 Minuten.

(6) *Mündliche Prüfungen* (§ 4 Abs. 2 Nr. 2) sind von mehreren Prüfenden (Kollegialprüfung) oder von einer/m Prüfenden in Gegenwart einer oder eines Beisitzenden als Gruppen- oder Einzelprüfungen abzunehmen und zu bewerten. Vor der Festsetzung der Note hört die/der Prüfende die anderen an der Kollegialprüfung mitwirkenden Prüfenden an. Mündliche Prüfungen dauern in der Regel mindestens 15 Minuten und maximal 60 Minuten pro Studierenden.

Die wesentlichen Gegenstände und Ergebnisse der *mündlichen Prüfung* sind in einem Protokoll festzuhalten. Das Ergebnis der Prüfung ist den Studierenden im Anschluss an die mündliche Prüfung bekannt zu geben.

Studierende, die sich in einem späteren Semester der gleichen Prüfung unterziehen wollen, werden entsprechend den räumlichen Verhältnissen und nach Zustimmung des Prüflings als Zuhörerinnen und Zuhörer bei mündlichen Prüfungen zugelassen. Die Zulassung erstreckt sich nicht auf die Beratung und Bekanntgabe der Prüfungsergebnisse.

(7) Für *Prüfungsleistungen anderer Art* (§ 4 Abs. 2 Nr. 3) sind angemessene Bearbeitungsfristen einzuräumen und Abgabetermine festzulegen. Dabei ist durch die Art der Aufgabenstellung und durch entsprechende Dokumentation sicherzustellen, dass die erbrachte Prüfungsleistung dem/der Studierenden zurechenbar ist. Die wesentlichen Gegenstände und Ergebnisse der Erfolgskontrolle sind in einem Protokoll festzuhalten.

Bei *mündlich* durchgeführten *Prüfungsleistungen anderer Art* muss neben der/dem Prüfenden ein/e Beisitzende/r anwesend sein, die/der zusätzlich zum/r Prüfenden das Protokoll zeichnet.

Schriftliche Arbeiten im Rahmen einer *Prüfungsleistung anderer Art* haben dabei die folgende Erklärung zu tragen: „Ich versichere wahrheitsgemäß, die Arbeit selbstständig angefertigt, alle benutzten Hilfsmittel vollständig und genau angegeben und alles kenntlich gemacht zu haben, was aus Arbeiten anderer unverändert oder mit Abänderungen entnommen wurde.“ Trägt die Arbeit diese Erklärung nicht, wird sie nicht angenommen. Die wesentlichen Gegenstände und Ergebnisse einer solchen Erfolgskontrolle sind in einem Protokoll festzuhalten.

§ 6 a Erfolgskontrollen im Antwort-Wahl-Verfahren

Das Modulhandbuch regelt, ob und in welchem Umfang Erfolgskontrollen im Wege des *Antwort-Wahl-Verfahrens* abgelegt werden können

§ 6 b Computergestützte Erfolgskontrollen

(1) Erfolgskontrollen können computergestützt durchgeführt werden. Dabei wird die Antwort bzw. Lösung der/des Studierenden elektronisch übermittelt und, sofern möglich, automatisiert ausgewertet. Die Prüfungsinhalte sind von einer/einem Prüfenden zu erstellen.
(2) Vor der computergestützten Erfolgskontrolle hat die/der Prüfende sicherzustellen, dass die elektronischen Daten eindeutig identifiziert und unverwechselbar und dauerhaft den Studierenden zugeordnet werden können. Der störungsfreie Verlauf einer computergestützten Erfolgskontrolle ist durch entsprechende technische Betreuung zu gewährleisten, insbesondere ist die Erfolgskontrolle in Anwesenheit einer fachlich sachkundigen Person durchzuführen. Alle Prüfungsaufgaben müssen während der gesamten Bearbeitungszeit zur Bearbeitung zur Verfügung stehen.

(3) Im Übrigen gelten für die Durchführung von computergestützten Erfolgskontrollen die §§ 6 bzw. 6 a.

§ 7 Bewertung von Studien- und Prüfungsleistungen

(1) Das Ergebnis einer Prüfungsleistung wird von den jeweiligen Prüfenden in Form einer Note festgesetzt.

(2) Folgende Noten sollen verwendet werden:

sehr gut (very good)	:	hervorragende Leistung,
gut (good)	:	eine Leistung, die erheblich über den durchschnittlichen Anforderungen liegt,
befriedigend (satisfactory)	:	eine Leistung, die durchschnittlichen Anforderungen entspricht,
ausreichend (sufficient)	:	eine Leistung, die trotz ihrer Mängel noch den Anforderungen genügt,
nicht ausreichend (failed)	:	eine Leistung, die wegen erheblicher Mängel nicht den Anforderungen genügt.

Zur differenzierten Bewertung einzelner Prüfungsleistungen sind nur folgende Noten zugelassen:

1,0; 1,3	:	sehr gut
1,7; 2,0; 2,3	:	gut
2,7; 3,0; 3,3	:	befriedigend
3,7; 4,0	:	ausreichend
5,0	:	nicht ausreichend

(3) Studienleistungen werden mit „bestanden“ oder mit „nicht bestanden“ gewertet.

(4) Bei der Bildung der gewichteten Durchschnitte der Modulnoten, der Fachnoten und der Gesamtnote wird nur die erste Dezimalstelle hinter dem Komma berücksichtigt; alle weiteren Stellen werden ohne Rundung gestrichen.

(5) Jedes Modul und jede Erfolgskontrolle darf in demselben Studiengang nur einmal gewertet werden.

(6) Eine Prüfungsleistung ist bestanden, wenn die Note mindestens „ausreichend“ (4,0) ist.

(7) Die Modulprüfung ist bestanden, wenn alle erforderlichen Erfolgskontrollen bestanden sind. Die Modulprüfung und die Bildung der Modulnote sollen im Modulhandbuch geregelt werden. Sofern das Modulhandbuch keine Regelung über die Bildung der Modulnote enthält, errechnet sich die Modulnote aus einem nach den Leistungspunkten der einzelnen Teilmodule gewichteter Notendurchschnitt. Die differenzierten Noten (Absatz 2) sind bei der Berechnung der Modulnoten als Ausgangsdaten zu verwenden.

(8) Die Ergebnisse der Erfolgskontrollen sowie die erworbenen Leistungspunkte werden durch den Studierendenservice des KIT verwaltet.

(9) Die Noten der Module eines Faches gehen in die Fachnote mit einem Gewicht proportional zu den ausgewiesenen Leistungspunkten der Module ein.

(10) Die Gesamtnote der Masterprüfung, die Fachnoten und die Modulnoten lauten:

		bis	1,5	=	sehr gut
von	1,6	bis	2,5	=	gut
von	2,6	bis	3,5	=	befriedigend
von	3,6	bis	4,0	=	ausreichend

§ 8 Wiederholung von Erfolgskontrollen, endgültiges Nichtbestehen

(1) Studierende können eine nicht bestandene schriftliche Prüfung (§ 4 Absatz 2 Nr. 1) einmal wiederholen. Wird eine schriftliche Wiederholungsprüfung mit „nicht ausreichend“ (5,0) bewertet, so findet eine mündliche Nachprüfung im zeitlichen Zusammenhang mit dem Termin der nicht bestandenen Prüfung statt. In diesem Falle kann die Note dieser Prüfung nicht besser als „ausreichend“ (4,0) sein.

(2) Studierende können eine nicht bestandene mündliche Prüfung (§ 4 Absatz 2 Nr. 2) einmal wiederholen.

(3) Wiederholungsprüfungen nach Absatz 1 und 2 müssen in Inhalt, Umfang und Form (mündlich oder schriftlich) der ersten entsprechen. Ausnahmen kann der zuständige Prüfungsausschuss auf Antrag zulassen.

(4) Prüfungsleistungen anderer Art (§ 4 Absatz 2 Nr. 3) können einmal wiederholt werden.

(5) Studienleistungen können mehrfach wiederholt werden.

(6) Die Wiederholung von Prüfungsleistungen hat spätestens bis zum Ende des Prüfungszeitraumes des übernächsten Semesters zu erfolgen.

(7) Die Prüfungsleistung ist endgültig nicht bestanden, wenn die mündliche Nachprüfung im Sinne des Absatzes 1 mit „nicht ausreichend“ (5,0) bewertet wurde. Die Prüfungsleistung ist ferner endgültig nicht bestanden, wenn die mündliche Prüfung im Sinne des Absatzes 2 oder die Prüfungsleistung anderer Art gemäß Absatz 4 zweimal mit „nicht bestanden“ bewertet wurde.

(8) Das Modul ist endgültig nicht bestanden, wenn eine für sein Bestehen erforderliche Prüfungsleistung endgültig nicht bestanden ist.

(9) Eine zweite Wiederholung derselben Prüfungsleistung gemäß § 4 Abs. 2 ist nur in Ausnahmefällen auf Antrag des/der Studierenden zulässig („Antrag auf Zweitwiederholung“). Der Antrag ist schriftlich beim Prüfungsausschuss in der Regel bis zwei Monate nach Bekanntgabe der Note zu stellen.

Über den ersten Antrag eines/einer Studierenden auf Zweitwiederholung entscheidet der Prüfungsausschuss, wenn er den Antrag genehmigt. Wenn der Prüfungsausschuss diesen Antrag ablehnt, entscheidet ein Mitglied des Präsidiums. Über weitere Anträge auf Zweitwiederholung entscheidet nach Stellungnahme des Prüfungsausschusses ein Mitglied des Präsidiums. Wird der Antrag genehmigt, hat die Zweitwiederholung spätestens zum übernächsten Prüfungstermin zu erfolgen. Absatz 1 Satz 2 und 3 gelten entsprechend.

(10) Die Wiederholung einer bestandenen Prüfungsleistung ist nicht zulässig.

(11) Die Masterarbeit kann bei einer Bewertung mit „nicht ausreichend“ (5,0) einmal wiederholt werden. Eine zweite Wiederholung der Masterarbeit ist ausgeschlossen.

§ 9 Verlust des Prüfungsanspruchs

Ist eine nach dieser Studien- und Prüfungsordnung erforderliche Studien- oder Prüfungsleistung endgültig nicht bestanden oder eine Wiederholungsprüfung nach § 8 Abs. 6 nicht rechtzeitig erbracht oder die Masterprüfung bis zum Ende des Prüfungszeitraums des siebenten Fachsemesters einschließlich etwaiger Wiederholungen nicht vollständig abgelegt, so erlischt der Prüfungsanspruch im Studiengang Maschinenbau, es sei denn, dass die Fristüberschreitung nicht selbst zu vertreten ist. Die Entscheidung über eine Fristverlängerung und über Ausnahmen von der Fristregelung trifft der Prüfungsausschuss unter Beachtung der in § 32 Abs. 6 LHG genannten Tätigkeiten auf Antrag des/der Studierenden. Der Antrag ist schriftlich in der Regel bis sechs Wochen vor Ablauf der Frist zu stellen.

§ 10 Abmeldung; Versäumnis, Rücktritt

(1) Studierende können ihre Anmeldung zu *schriftlichen Prüfungen* ohne Angabe von Gründen bis zur Ausgabe der Prüfungsaufgaben widerrufen (Abmeldung). Eine Abmeldung kann online im Studierendenportal bis 24:00 Uhr des Vortages der Prüfung oder in begründeten Ausnahmefällen beim Studierendenservice innerhalb der Geschäftszeiten erfolgen. Erfolgt die Abmeldung gegenüber dem/der Prüfenden hat diese/r Sorge zu tragen, dass die Abmeldung im Campus Management System verbucht wird.

(2) Bei *mündlichen Prüfungen* muss die Abmeldung spätestens drei Werktage vor dem betreffenden Prüfungstermin gegenüber dem/der Prüfenden erklärt werden. Der Rücktritt von einer mündlichen Prüfung weniger als drei Werktage vor dem betreffenden Prüfungstermin ist nur unter den Voraussetzungen des Absatzes 5 möglich. Der Rücktritt von mündlichen Nachprüfungen im Sinne von § 9 Abs. 1 ist grundsätzlich nur unter den Voraussetzungen von Absatz 5 möglich.

(3) Die Abmeldung von *Prüfungsleistungen anderer Art* sowie von *Studienleistungen* ist im Modulhandbuch geregelt.

(4) Eine Erfolgskontrolle gilt als mit „nicht ausreichend“ (5,0) bewertet, wenn die Studierenden einen Prüfungstermin ohne triftigen Grund versäumen oder wenn sie nach Beginn der Erfolgskontrolle ohne triftigen Grund von dieser zurücktreten. Dasselbe gilt, wenn die Masterarbeit nicht innerhalb der vorgesehenen Bearbeitungszeit erbracht wird, es sei denn, der/die Studierende hat die Fristüberschreitung nicht zu vertreten.

(5) Der für den Rücktritt nach Beginn der Erfolgskontrolle oder das Versäumnis geltend gemachte Grund muss dem Prüfungsausschuss unverzüglich schriftlich angezeigt und glaubhaft gemacht werden. Bei Krankheit des/der Studierenden oder eines allein zu versorgenden Kindes oder pflegebedürftigen Angehörigen kann die Vorlage eines ärztlichen Attestes verlangt werden.

§ 11 Täuschung, Ordnungsverstoß

(1) Versuchen Studierende das Ergebnis ihrer Erfolgskontrolle durch Täuschung oder Benutzung nicht zugelassener Hilfsmittel zu beeinflussen, gilt die betreffende Erfolgskontrolle als mit „nicht ausreichend“ (5,0) bewertet.

(2) Studierende, die den ordnungsgemäßen Ablauf einer Erfolgskontrolle stören, können von der/dem Prüfenden oder der Aufsicht führenden Person von der Fortsetzung der Erfolgskontrolle ausgeschlossen werden. In diesem Fall gilt die betreffende Erfolgskontrolle als mit „nicht ausreichend“ (5,0) bewertet. In schwerwiegenden Fällen kann der Prüfungsausschuss diese Studierenden von der Erbringung weiterer Erfolgskontrollen ausschließen.

(3) Näheres regelt die Allgemeine Satzung des KIT zur Redlichkeit bei Prüfungen und Praktika in der jeweils gültigen Fassung.

§ 12 Mutterschutz, Elternzeit, Wahrnehmung von Familienpflichten

(1) Auf Antrag sind die Mutterschutzfristen, wie sie im jeweils gültigen Gesetz zum Schutz der erwerbstätigen Mutter (Mutterschutzgesetz - MuSchG) festgelegt sind, entsprechend zu berücksichtigen. Dem Antrag sind die erforderlichen Nachweise beizufügen. Die Mutterschutzfristen unterbrechen jede Frist nach dieser Prüfungsordnung. Die Dauer des Mutterschutzes wird nicht in die Frist eingerechnet.

(2) Gleichfalls sind die Fristen der Elternzeit nach Maßgabe des jeweils gültigen Gesetzes (Bundeselterngeld- und Elternzeitgesetz - BEEG) auf Antrag zu berücksichtigen. Der/die Studierende muss bis spätestens vier Wochen vor dem Zeitpunkt, von dem an die Elternzeit angetreten werden soll, dem Prüfungsausschuss, unter Beifügung der erforderlichen Nachweise schriftlich mitteilen, in welchem Zeitraum die Elternzeit in Anspruch genommen werden soll. Der Prüfungsausschuss hat zu prüfen, ob die gesetzlichen Voraussetzungen vorliegen, die bei einer Arbeitnehmerin bzw. einem Arbeitnehmer den Anspruch auf Elternzeit auslösen würden, und teilt dem/der Studierenden das Ergebnis sowie die neu festgesetzten Prüfungszeiten unverzüglich mit. Die Bearbeitungszeit der Masterarbeit kann nicht durch Elternzeit unterbrochen werden. Die gestellte Arbeit gilt als nicht vergeben. Nach Ablauf der Elternzeit erhält der/die Studierende ein neues Thema, das innerhalb der in § 14 festgelegten Bearbeitungszeit zu bearbeiten ist.

(3) Der Prüfungsausschuss entscheidet auf Antrag über die flexible Handhabung von Prüfungsfristen entsprechend den Bestimmungen des Landeshochschulgesetzes, wenn Studierende Familienpflichten wahrzunehmen haben. Absatz 2 Satz 4 bis 6 gelten entsprechend.

§ 13 Studierende mit Behinderung oder chronischer Erkrankung

(1) Bei der Gestaltung und Organisation des Studiums sowie der Prüfungen sind die Belange von Studierenden mit Behinderung oder chronischer Erkrankung zu berücksichtigen. Insbesondere ist Studierenden mit Behinderung oder chronischer Erkrankung bevorzugter Zugang zu teilnahmebegrenzten Lehrveranstaltungen zu gewähren und die Reihenfolge für das Absolvieren bestimmter Lehrveranstaltungen entsprechend ihrer Bedürfnisse anzupassen. Studierende sind gemäß Bundesgleichstellungsgesetz (BGG) und Sozialgesetzbuch Neuntes Buch (SGB IX) behindert, wenn ihre körperliche Funktion, geistige Fähigkeit oder seelische Gesundheit mit hoher Wahrscheinlichkeit länger als sechs Monate von dem für das Lebensalter typischen Zustand abweichen und daher ihre Teilhabe am Leben in der Gesellschaft beeinträchtigt ist. Der Prüfungsausschuss entscheidet auf Antrag der/des Studierenden über das Vorliegen der Voraussetzungen nach Satz 2 und 3. Die/der Studierende hat die entsprechenden Nachweise vorzulegen.

(2) Weisen Studierende eine Behinderung oder chronische Erkrankung nach und folgt daraus, dass sie nicht in der Lage sind, Erfolgskontrollen ganz oder teilweise in der vorgeschriebenen Zeit oder Form abzulegen, kann der Prüfungsausschuss gestatten, die Erfolgskontrollen in einem anderen Zeitraum oder einer anderen Form zu erbringen. Insbesondere ist behinderten Studierenden zu gestatten, notwendige Hilfsmittel zu benutzen.

(3) Weisen Studierende eine Behinderung oder chronische Erkrankung nach und folgt daraus, dass sie nicht in der Lage sind, die Lehrveranstaltungen regelmäßig zu besuchen oder die gemäß § 19 erforderlichen Studien- und Prüfungsleistungen zu erbringen, kann der Prüfungsausschuss auf Antrag gestatten, dass einzelne Studien- und Prüfungsleistungen nach Ablauf der in dieser Studien- und Prüfungsordnung vorgesehenen Fristen absolviert werden können.

§ 14 Modul Masterarbeit

(1) Voraussetzung für die Zulassung zum Modul Masterarbeit ist, dass die/der Studierende Modulprüfungen im Umfang von 74 LP erfolgreich abgelegt hat. Über Ausnahmen entscheidet der Prüfungsausschuss auf Antrag der/des Studierenden.

(1 a) Dem Modul Masterarbeit sind 30 LP zugeordnet. Es besteht aus der Masterarbeit und einer Präsentation. Die Präsentation hat spätestens sechs Wochen nach Abgabe der Masterarbeit zu erfolgen.

(2) Die Masterarbeit kann von Hochschullehrer/innen und leitenden Wissenschaftler/innen gemäß § 14 Abs. 3 Ziff. 1 KITG vergeben werden. Darüber hinaus kann der Prüfungsausschuss weitere Prüfende gemäß § 17 Abs. 2 und 3 zur Vergabe des Themas berechtigen. Den Studierenden ist Gelegenheit zu geben, für das Thema Vorschläge zu machen. Soll die Masterarbeit außerhalb der KIT-Fakultät für Maschinenbau angefertigt werden, so bedarf dies der Genehmigung durch den Prüfungsausschuss. Die Masterarbeit kann auch in Form einer Gruppenarbeit zugelassen werden, wenn der als Prüfungsleistung zu bewertende Beitrag der einzelnen Studierenden aufgrund objektiver Kriterien, die eine eindeutige Abgrenzung ermöglichen, deutlich unterscheidbar ist und die Anforderung nach Absatz 4 erfüllt. In Ausnahmefällen sorgt die/der Vorsitzende des Prüfungsausschusses auf Antrag der oder des Studierenden dafür, dass die/der Studierende innerhalb von vier Wochen ein Thema für die Masterarbeit erhält. Die Ausgabe des Themas erfolgt in diesem Fall über die/den Vorsitzende/n des Prüfungsausschusses.

(3) Thema, Aufgabenstellung und Umfang der Masterarbeit sind von dem Betreuer bzw. der Betreuerin so zu begrenzen, dass sie mit dem in Absatz 4 festgelegten Arbeitsaufwand bearbeitet werden kann.

(4) Die Masterarbeit soll zeigen, dass die Studierenden in der Lage sind, ein Problem aus ihrem Studienfach selbstständig und in begrenzter Zeit nach wissenschaftlichen Methoden zu bearbeiten. Der Umfang der Masterarbeit entspricht 30 Leistungspunkten. Die maximale Bearbeitungsdauer beträgt sechs Monate. Thema und Aufgabenstellung sind an den vorgesehenen Umfang anzupassen. Der Prüfungsausschuss legt fest, in welchen Sprachen die Masterarbeit geschrieben werden kann. Auf Antrag des Studierenden kann der/die Prüfende genehmigen, dass die Masterarbeit in einer anderen Sprache als Deutsch geschrieben wird.

(5) Bei der Abgabe der Masterarbeit haben die Studierenden schriftlich zu versichern, dass sie die Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt haben, die wörtlich oder inhaltlich übernommenen Stellen als solche kenntlich gemacht und die Satzung des KIT zur Sicherung guter wissenschaftlicher Praxis in der jeweils gültigen Fassung beachtet haben. Wenn diese Erklärung nicht enthalten ist, wird die Arbeit nicht angenommen. Die Erklärung kann wie folgt lauten: „Ich versichere wahrheitsgemäß, die Arbeit selbstständig verfasst, alle benutzten 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.“ Bei Abgabe einer unwahren Versicherung wird die Masterarbeit mit „nicht ausreichend“ (5,0) bewertet.

(6) Der Zeitpunkt der Ausgabe des Themas der Masterarbeit ist durch die Betreuerin/den Betreuer und die/den Studierenden festzuhalten und dies beim Prüfungsausschuss aktenkundig zu machen. Der Zeitpunkt der Abgabe der Masterarbeit ist durch den/die Prüfende/n beim Prüfungsausschuss aktenkundig zu machen. Das Thema kann nur einmal und nur innerhalb des ersten Monats der Bearbeitungszeit zurückgegeben werden. Macht der oder die Studierende einen triftigen Grund geltend, kann der Prüfungsausschuss die in Absatz 4 festgelegte Bearbeitungszeit auf Antrag der oder des Studierenden um höchstens drei Monate verlängern. Wird die Masterarbeit nicht fristgerecht abgeliefert, gilt sie als mit „nicht ausreichend“ (5,0) bewertet, es sei denn, dass die Studierenden dieses Versäumnis nicht zu vertreten haben.

(7) Die Masterarbeit wird von mindestens einem/einer Hochschullehrer/in oder einem/einer leitenden Wissenschaftler/in gemäß § 14 abs. 3 Ziff. 1 KITG und einem/einer weiteren Prüfenden bewertet. In der Regel ist eine/r der Prüfenden die Person, die die Arbeit gemäß Absatz 2 vergeben hat. Bei nicht übereinstimmender Beurteilung dieser beiden Personen setzt der Prüfungsausschuss im Rahmen der Bewertung dieser beiden Personen die Note der Masterarbeit fest; er kann auch einen weiteren Gutachter bestellen. Die Bewertung hat innerhalb von sechs Wochen nach Abgabe der Masterarbeit zu erfolgen.

§ 15 Zusatzleistungen

(1) Es können auch weitere Leistungspunkte (Zusatzleistungen) im Umfang von höchstens 30 LP aus dem Gesamtangebot des KIT erworben werden. § 3 und § 4 der Prüfungsordnung bleiben davon unberührt. Diese Zusatzleistungen gehen nicht in die Festsetzung der Gesamt- und Modulnoten ein. Die bei der Festlegung der Modulnote nicht berücksichtigten LP werden als Zusatzleistungen im Transcript of Records aufgeführt und als Zusatzleistungen gekennzeichnet. Auf Antrag der/des Studierenden werden die Zusatzleistungen in das Masterzeugnis aufgenommen und als Zusatzleistungen gekennzeichnet. Zusatzleistungen werden mit den nach § 7 vorgesehenen Noten gelistet.

(2) Die Studierenden haben bereits bei der Anmeldung zu einer Prüfung in einem Modul diese als Zusatzleistung zu deklarieren.

§ 16 Prüfungsausschuss

(1) Für den Masterstudiengang Maschinenbau wird ein Prüfungsausschuss gebildet. Er besteht aus vier stimmberechtigten Mitgliedern: zwei Hochschullehrer/innen / leitenden Wissenschaftler/innen gemäß § 14 Abs. 3 Ziff. 1 KITG / Privatdozentinnen bzw. -dozenten, zwei akademischen Mitarbeiterinnen und Mitarbeitern nach § 52 LHG / wissenschaftlichen Mitarbeiter/innen gemäß § 14 Abs. 3 Ziff. 2 KITG und einer bzw. einem Studierenden mit beratender Stimme. Im Falle der Einrichtung eines gemeinsamen Prüfungsausschusses für den Bachelor- und den Masterstudiengang Maschinenbau erhöht sich die Anzahl der Studierenden auf zwei Mitglieder mit beratender Stimme, wobei je eine bzw. einer dieser beiden aus dem Bachelor- und aus dem Masterstudiengang stammt. Die Amtszeit der nichtstudentischen Mitglieder beträgt zwei Jahre, die des studentischen Mitglieds ein Jahr.

(2) Die/der Vorsitzende, ihre/sein Stellvertreter/in, die weiteren Mitglieder des Prüfungsausschusses sowie deren Stellvertreter/innen werden von dem KIT-Fakultätsrat bestellt, die akademischen Mitarbeiter/innen nach § 52 LHG, die wissenschaftlichen Mitarbeiter gemäß § 14 Abs. 3 Ziff. 2 KITG und die Studierenden auf Vorschlag der Mitglieder der jeweiligen Gruppe; Wiederbestellung ist möglich. Die/der Vorsitzende und deren/dessen Stellvertreter/in müssen Hochschullehrer/innen oder leitende Wissenschaftler/innen § 14 Abs. 3 Ziff. 1 KITG sein. Die/der Vorsitzende des Prüfungsausschusses nimmt die laufenden Geschäfte wahr und wird durch das jeweilige Prüfungssekretariat unterstützt.

(3) Der Prüfungsausschuss achtet auf die Einhaltung der Bestimmungen dieser Studien- und Prüfungsordnung und fällt die Entscheidungen in Prüfungsangelegenheiten. Er entscheidet über die Anerkennung von Studienzeiten sowie Studien- und Prüfungsleistungen und trifft die Feststellung gemäß § 18 Absatz 1 Satz 1. Er berichtet der KIT-Fakultät regelmäßig über die Entwicklung der Prüfungs- und Studienzeiten, einschließlich der Bearbeitungszeiten für die Masterarbeiten und die Verteilung der Modul- und Gesamtnoten. Er ist zuständig für Anregungen zur Reform der Studien- und Prüfungsordnung und zu Modulbeschreibungen. Der Prüfungsausschuss entscheidet mit der Mehrheit seiner Stimmen. Bei Stimmengleichheit entscheidet der Vorsitzende des Prüfungsausschusses.

(4) Der Prüfungsausschuss kann die Erledigung seiner Aufgaben für alle Regelfälle auf die/den Vorsitzende/n des Prüfungsausschusses übertragen. In dringenden Angelegenheiten, deren Erledigung nicht bis zu der nächsten Sitzung des Prüfungsausschusses warten kann, entscheidet die/der Vorsitzende des Prüfungsausschusses.

(5) Die Mitglieder des Prüfungsausschusses haben das Recht, der Abnahme von Prüfungen beizuwohnen. Die Mitglieder des Prüfungsausschusses, die Prüfenden und die Beisitzenden unterliegen der Verschwiegenheit. Sofern sie nicht im öffentlichen Dienst stehen, sind sie durch die/den Vorsitzende/n zur Verschwiegenheit zu verpflichten.

(6) In Angelegenheiten des Prüfungsausschusses, die eine an einer anderen KIT-Fakultät zu absolvierende Prüfungsleistung betreffen, ist auf Antrag eines Mitgliedes des Prüfungsausschusses eine fachlich zuständige und von der betroffenen KIT-Fakultät zu nennende prüfungsberechtigte Person hinzuzuziehen.

(7) Belastende Entscheidungen des Prüfungsausschusses sind schriftlich mitzuteilen. Sie sind zu begründen und mit einer Rechtsbehelfsbelehrung zu versehen. Vor einer Entscheidung ist Gelegenheit zur Äußerung zu geben. Widersprüche gegen Entscheidungen des Prüfungsausschusses sind innerhalb eines Monats nach Zugang der Entscheidung schriftlich oder zur Niederschrift beim Präsidium des KIT einzulegen.

§ 17 Prüfende und Beisitzende

(1) Der Prüfungsausschuss bestellt die Prüfenden. Er kann die Bestellung der/dem Vorsitzenden übertragen.

(2) Prüfende sind Hochschullehrer/innen sowie leitende Wissenschaftler/innen gemäß § 14 Abs. 3 Ziff. 1 KITG, habilitierte Mitglieder und akademische Mitarbeiter/innen gemäß § 52 LHG, welche der KIT-Fakultät angehören und denen die Prüfungsbefugnis übertragen wurde; desgleichen kann wissenschaftlichen Mitarbeitern gemäß § 14 Abs. 3 Ziff. 2 KITG die Prüfungsbefugnis übertragen werden. Bestellt werden darf nur, wer mindestens die dem jeweiligen Prüfungsgegenstand entsprechende fachwissenschaftliche Qualifikation erworben hat.

(3) Soweit Lehrveranstaltungen von anderen als den unter Absatz 2 genannten Personen durchgeführt werden, sollen diese zu Prüfenden bestellt werden, sofern die KIT-Fakultät eine Prüfungsbefugnis erteilt hat und sie die gemäß Absatz 2 Satz 2 vorausgesetzte Qualifikation nachweisen können.

(4) Die Beisitzenden werden durch die Prüfenden benannt. Zu Beisitzenden darf nur bestellt werden, wer einen akademischen Abschluss in einem mathematisch-naturwissenschaftlichen oder ingenieurwissenschaftlichen Studiengang oder einen gleichwertigen akademischen Abschluss erworben hat.

§ 18 Anerkennung von Studien- und Prüfungsleistungen, Studienzeiten

(1) Studien- und Prüfungsleistungen sowie Studienzeiten, die in Studiengängen an staatlichen oder staatlich anerkannten Hochschulen und Berufsakademien der Bundesrepublik Deutschland oder an ausländischen staatlichen oder staatlich anerkannten Hochschulen erbracht wurden, werden auf Antrag der Studierenden anerkannt, sofern hinsichtlich der erworbenen Kompetenzen kein wesentlicher Unterschied zu den Leistungen oder Abschlüssen besteht, die ersetzt werden sollen. Dabei ist kein schematischer Vergleich, sondern eine Gesamtbetrachtung vorzunehmen. Bezüglich des Umfangs einer zur Anerkennung vorgelegten Studienleistung bzw. Prüfungsleistung (Anrechnung) werden die Grundsätze des ECTS herangezogen.

(2) Die Studierenden haben die für die Anerkennung erforderlichen Unterlagen vorzulegen. Studierende, die neu in den Masterstudiengang Maschinenbau immatrikuliert wurden, haben den Antrag mit den für die Anerkennung erforderlichen Unterlagen innerhalb eines Semesters nach Immatrikulation zu stellen. Bei Unterlagen, die nicht in deutscher oder englischer Sprache vorliegen, kann eine amtlich beglaubigte Übersetzung verlangt werden. Die Beweislast dafür, dass der Antrag die Voraussetzungen für die Anerkennung nicht erfüllt, liegt beim Prüfungsausschuss.

(3) Werden Leistungen angerechnet, die nicht am KIT erbracht wurden, werden sie im Zeugnis als „anerkannt“ ausgewiesen. Liegen Noten vor, werden die Noten, soweit die Notensysteme vergleichbar sind, übernommen und in die Berechnung der Modulnoten und der Gesamtnote einbezogen. Sind die Notensysteme nicht vergleichbar, können die Noten umgerechnet werden. Liegen keine Noten vor, wird der Vermerk „bestanden“ aufgenommen.

(4) Bei der Anerkennung von Studien- und Prüfungsleistungen, die außerhalb der Bundesrepublik Deutschland erbracht wurden, sind die von der Kultusministerkonferenz und der Hochschul-

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rektorenkonferenz gebilligten Äquivalenzvereinbarungen sowie Absprachen im Rahmen der Hochschulpartnerschaften zu beachten.

(5) Außerhalb des Hochschulsystems erworbene Kenntnisse und Fähigkeiten werden angerechnet, wenn sie nach Inhalt und Niveau den Studien- und Prüfungsleistungen gleichwertig sind, die ersetzt werden sollen und die Institution, in der die Kenntnisse und Fähigkeiten erworben wurden, ein genormtes Qualitätssicherungssystem hat. Die Anrechnung kann in Teilen versagt werden, wenn mehr als 50 Prozent des Hochschulstudiums ersetzt werden soll.

(6) Zuständig für Anerkennung und Anrechnung ist der Prüfungsausschuss. Im Rahmen der Feststellung, ob ein wesentlicher Unterschied im Sinne des Absatz 1 vorliegt, sind die zuständigen Fachvertreter/innen zu hören. Der Prüfungsausschuss entscheidet in Abhängigkeit von Art und Umfang der anzurechnenden Studien- und Prüfungsleistungen über die Einstufung in ein höheres Fachsemester.

II. Masterprüfung

§ 19 Umfang und Art der Masterprüfung

(1) Die Masterprüfung besteht aus den Modulprüfungen nach Absatz 2 und 3 sowie der Modul Masterarbeit (§ 14).

(2) Es sind Modulprüfungen im Pflichtfach „Vertiefung ingenieurwissenschaftlicher Grundlagen" im Umfang von 50 LP abzulegen.

Die Festlegung der zur Auswahl stehenden Module wird im Modulhandbuch getroffen.

(3) Im Wahlpflichtbereich ist ein Wahlpflichtfach im Umfang von 40 LP zu absolvieren. Zur Auswahl steht mindestens das Fach „Allgemeiner Maschinenbau". Die Festlegung der weiteren zur Auswahl stehenden Fächer und der den Fächern zugeordneten Module wird im Modulhandbuch getroffen.

§ 20 Bestehen der Masterprüfung, Bildung der Gesamtnote

(1) Die Masterprüfung ist bestanden, wenn alle in § 19 genannten Modulprüfungen mindestens mit „ausreichend" bewertet wurden.

(2) Die Gesamtnote der Masterprüfung errechnet sich als ein mit Leistungspunkten gewichteter Notendurchschnitt der Fachnoten und dem Modul Masterarbeit.

(3) Haben Studierende die Masterarbeit mit der Note 1,0 und die Masterprüfung mit einem Durchschnitt von 1,2 oder besser abgeschlossen, so wird das Prädikat „mit Auszeichnung" (with distinction) verliehen.

§ 21 Masterzeugnis, Masterurkunde, Diploma Supplement und Transcript of Records

(1) Über die Masterprüfung werden nach Bewertung der letzten Prüfungsleistung eine Masterurkunde und ein Zeugnis erstellt. Die Ausfertigung von Masterurkunde und Zeugnis soll nicht später als drei Monate nach Ablegen der letzten Prüfungsleistung erfolgen. Masterurkunde und Masterzeugnis werden in deutscher und englischer Sprache ausgestellt. Masterurkunde und Zeugnis tragen das Datum der erfolgreichen Erbringung der letzten Prüfungsleistung. Diese Dokumente werden den Studierenden zusammen ausgehändigt. In der Masterurkunde wird die Verleihung des akademischen Mastergrades beurkundet. Die Masterurkunde wird von dem Präsidenten und der KIT-Dekanin/ dem KIT-Dekan der KIT-Fakultät unterzeichnet und mit dem Siegel des KIT versehen.

(2) Das Zeugnis enthält die Fach- und Modulnoten sowie die den Modulen und Fächern zugeordnete Leistungspunkte und die Gesamtnote. Sofern gemäß § 7 Abs. 2 Satz 2 eine differenzierte Bewertung einzelner Prüfungsleitungen vorgenommen wurde, wird auf dem Zeugnis auch die entsprechende Dezimalnote ausgewiesen; § 7 Abs. 4 bleibt unberührt. Das Zeugnis ist von der KIT-Dekanin/ dem KIT-Dekan der KIT-Fakultät und von der/dem Vorsitzenden des Prüfungsausschusses zu unterzeichnen.

(3) Mit dem Zeugnis erhalten die Studierenden ein Diploma Supplement in deutscher und englischer Sprache, das den Vorgaben des jeweils gültigen ECTS Users‘ Guide entspricht, sowie ein Transcript of Records in deutscher und englischer Sprache.

(4) Das Transcript of Records enthält in strukturierter Form alle erbrachten Studien- und Prüfungsleistungen. Dies beinhaltet alle Fächer und Fachnoten samt den zugeordneten Leistungspunkten, die dem jeweiligen Fach zugeordneten Module mit den Modulnoten und zugeordneten Leistungspunkten sowie die den Modulen zugeordneten Erfolgskontrollen samt Noten und zugeordneten Leistungspunkten. Absatz 2 Satz 2 gilt entsprechend. Aus dem Transcript of Records soll die Zugehörigkeit von Lehrveranstaltungen zu den einzelnen Modulen deutlich erkennbar sein. Angerechnete Studien- und Prüfungsleistungen sind im Transcript of Records aufzunehmen. Alle Zusatzleistungen werden im Transcript of Records aufgeführt.

(5) Die Masterurkunde, das Masterzeugnis und das Diploma Supplement, einschließlich des Transcript of Records, werden vom Studierendenservice des KIT ausgestellt.

III. Schlussbestimmungen

§ 22 Bescheinigung von Prüfungsleistungen

Haben Studierende die Masterprüfung endgültig nicht bestanden, wird ihnen auf Antrag und gegen Vorlage der Exmatrikulationsbescheinigung eine schriftliche Bescheinigung ausgestellt, die die erbrachten Studien- und Prüfungsleistungen und deren Noten enthält und erkennen lässt, dass die Prüfung insgesamt nicht bestanden ist. Dasselbe gilt, wenn der Prüfungsanspruch erloschen ist.

§ 23 Aberkennung des Mastergrades

(1) Haben Studierende bei einer Prüfungsleistung getäuscht und wird diese Tatsache nach der Aushändigung des Zeugnisses bekannt, so können die Noten der Modulprüfungen, bei denen getäuscht wurde, berichtigt werden. Gegebenenfalls kann die Modulprüfung für „nicht ausreichend“ (5,0) und die Masterprüfung für „nicht bestanden“ erklärt werden.

(2) Waren die Voraussetzungen für die Zulassung zu einer Prüfung nicht erfüllt, ohne dass die/der Studierende darüber täuschen wollte, und wird diese Tatsache erst nach Aushändigung des Zeugnisses bekannt, wird dieser Mangel durch das Bestehen der Prüfung geheilt. Hat die/der Studierende die Zulassung vorsätzlich zu Unrecht erwirkt, so kann die Modulprüfung für „nicht ausreichend“ (5,0) und die Masterprüfung für „nicht bestanden“ erklärt werden.

(3) Vor einer Entscheidung des Prüfungsausschusses ist Gelegenheit zur Äußerung zu geben.

(4) Das unrichtige Zeugnis ist zu entziehen und gegebenenfalls ein neues zu erteilen. Mit dem unrichtigen Zeugnis ist auch die Masterurkunde einzuziehen, wenn die Masterprüfung aufgrund einer Täuschung für „nicht bestanden“ erklärt wurde.

(5) Eine Entscheidung nach Absatz 1 und Absatz 2 Satz 2 ist nach einer Frist von fünf Jahren ab dem Datum des Zeugnisses ausgeschlossen.

(6) Die Aberkennung des akademischen Grades richtet sich nach § 36 Abs. 7 LHG.

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§ 24 Einsicht in die Prüfungsakten

(1) Nach Abschluss der Masterprüfung wird den Studierenden auf Antrag innerhalb eines Jahres Einsicht in das Prüfungsexemplar ihrer Masterarbeit, die darauf bezogenen Gutachten und in die Prüfungsprotokolle gewährt.

(2) Für die Einsichtnahme in die schriftlichen Modulprüfungen, schriftlichen Modulteilprüfungen bzw. Prüfungsprotokolle gilt eine Frist von einem Monat nach Bekanntgabe des Prüfungsergebnisses.

(3) Der/die Prüfende bestimmt Ort und Zeit der Einsichtnahme.

(4) Prüfungsunterlagen sind mindestens fünf Jahre aufzubewahren.

§ 25 Inkrafttreten, Übergangsvorschriften

(1) Diese Studien- und Prüfungsordnung tritt am 01. Oktober 2016 in Kraft.

(2) Gleichzeitig tritt die Studien- und Prüfungsordnung des KIT für den Masterstudiengang Maschinenbau vom 28. Februar 2008 (Amtliche Bekanntmachung des KIT Nr. 79 vom 09. September 2008), zuletzt geändert durch Satzung vom 24. September 2014 (Amtliche Bekanntmachung des KIT Nr. 54 vom 01. Oktober 2014), außer Kraft.

(3) Studierende, die auf Grundlage der Studien- und Prüfungsordnung für den Masterstudiengang Maschinenbau vom 28. Februar 2008 (Amtliche Bekanntmachung des KIT Nr. 79 vom 09. September 2008), zuletzt geändert durch Satzung vom 24. September 2014 (Amtliche Bekanntmachung des KIT Nr. 54 vom 01. Oktober 2014), ihr Studium am KIT aufgenommen haben, können Prüfungen auf Grundlage dieser Studien- und Prüfungsordnung letztmalig am 30. September 2020 ablegen.

(4) Studierende, die auf Grundlage der Studien- und Prüfungsordnung für den Masterstudiengang Maschinenbau vom 28. Februar 2008 (Amtliche Bekanntmachung des KIT Nr. 79 vom 09. September 2008), zuletzt geändert durch Satzung vom 24. September 2014 (Amtliche Bekanntmachung des KIT Nr. 54 vom 01. Oktober 2014), ihr Studium am KIT aufgenommen haben, können auf Antrag ihr Studium nach der vorliegenden Studien- und Prüfungsordnung fortsetzen.

(5) Die Prüfungsordnung für den Diplomstudiengang Maschinenbau vom 27. Juli 2000 (Amtliche Bekanntmachung der Universität Karlsruhe (TH) Nr. 18 vom 15. August 2000, S. 107 ff.) bleibt außer Kraft. Studierende, die auf Grundlage der Prüfungsordnung für den Diplomstudiengang Maschinenbau vom 27. Juli 2000 (Amtliche Bekanntmachung der Universität Karlsruhe (TH) Nr. 18 vom 15. August 2000, S. 107 ff.) ihr Studium an der Universität Karlsruhe (TH) aufgenommen haben, können die Diplomprüfung einschließlich etwaiger Wiederholungen letztmalig bis zum 30. September 2017 ablegen.

Karlsruhe, den 04. August 2015

Professor Dr.-Ing. Holger Hanselka
(Präsident)

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