Karlsruhe Institute of Technology

Module Handbook
Mechanical Engineering (B.Sc.)

Valid from Winter Term 2018/2019
Long version, SPO 2015
valid for study beginners until WT 2017-2018

Faculty of Mechanical Engineering

KIT - University of the State of Baden-Wuerttemberg and
National Research Center of the Helmholtz Association

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Studienplan der KIT-Fakultät für Maschinenbau für den Bachelorstudiengang Maschinenbau gemäß SPO 2015

Fassung vom 18. Juni 2018

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0 Abkürzungsverzeichnis

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
	E(P), E/P	Teilleistung Praktikum im Ergänzungsbereich des Schwerpunkts, unbenotet
Lehrveranstaltung:	V	Vorlesung
	Ü	Übung
	P	Praktikum
	SWS	Semesterwochenstunden
Teilleistung:	LP	Leistungspunkte
	Pr	Prüfung
	mPr	mündliche Prüfung
	sPr	schriftliche Prüfung
	PraA	Prüfungsleistung anderer Art
	Üschein	Übungsschein
	Pschein	Praktikumsschein
	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

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 von der Prüfungskommission 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 sechs 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 können solange beliebig oft wiederholt werden, bis diese erfolgreich bestanden wurden.

1.2 Module des Bachelorstudiums

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

Das in § 16 SPO beschriebene Fach „Überfachliche Qualifikationen" bildet das Modul „Schlüsselqualifikationen" mit einem Umfang von 6 Leistungspunkten.

Fach	Modul	LP/ Modul	Teilleistung	LP/ TL	Koordinator	Art der Erfolgskontrolle		Pr (h)	Gew
						Studienleistungen	Prüfungsleistungen		
Ingenieurwissenschaftliche Grundlagen	Höhere Mathematik	21	Höhere Mathematik I	7	Kirsch	Üschein	sPr	2	7
			Höhere Mathematik II	7		ÜSchein	sPr	2	7
			Höhere Mathematik III	7		ÜSchein	sPr	2	7
	Technische Mechanik	23	Technische Mechanik I	7	Böhlke	Üschein	sPr	01:30	7
			Technische Mechanik II	6		Üschein	sPr	01:30	6
			Technische Mechanik III & IV	10	Seemann	Üschein Üschein	sPr	3	10
	Werkstoffkunde	14	Werkstoffkunde I & II	11	Heilmaier		mPr	ca. 00:30	14
			Werkstoffkunde-Praktikum	3		Pschein			
	Technische Thermodynamik	15	Technische Thermodynamik und Wärmeübertragung I	8	Maas	Üschein	sPr	3	8
			Technische Thermodynamik und Wärmeübertragung II	7		Üschein	sPr	3	7
	Strömungslehre	8	Strömungslehre I & II	8	Frohnapfel		sPr	3	8
	Physik	5	Wellen- und Quantenphysik	5	Pilawa		sPr	2	5
	Elektrotechnik	8	Elektrotechnik und Elektronik	8	Becker		sPr	3	8
	Mess- und Regelungstechnik	7	Grundlagen der Mess- und Regelungstechnik	7	Stiller		sPr	2,5	7

Fach	Modul	LP/ Modul	Teilleistung	LP/ TL	Koordinator	Art der Erfolgs-kontrolle		Pr (h)	Gew
						Studien-leistungen	Prüfungs-leistungen		
	Informatik	6	Informatik im Maschinenbau	6	Ovtcharova	Pschein	sPr	3	6
	Maschinenkon-struktionslehre	20	Maschinenkonstruk-tionslehre I & II	7	Albers	Üschein Üschein	sPr	1	7
			Maschinenkonstruk-tionslehre III & IV	13		Üschein Üschein	sPr	4	13
	Maschinen und Prozesse	7	Maschinen und Prozesse	7	Kubach	Pschein	sPr	3	7
	Fertigungspro-zesse	4	Grundlagen der Fertigungstechnik	4	Schulze		sPr	1	4
	Betriebliche Produktionswirt-schaft	5	Betriebliche Produktionswirtschaft	3	Furmans		sPr	01:30	5
			Betriebliche Produktionswirtschaft Projekt	2			PraA		
Vertiefung im Maschinenbau	Schwerpunkt	12	Kernbereich, wählbare TL s. Modulhandbuch	8	SP-Verantwort-licher		mPr	ca. 00:40	8
			Ergänzungsbereich, wählbare TL s. Modul-handbuch	4			mPr	ca. 00:20	4
	Wahlpflicht-modul	4	wählbare TL s. Modul-handbuch	4	Heilmaier		mPr	ca. 00:20	4
Überfachliche Qualifikationen	Schlüssel-qualifikationen	6	Arbeitstechniken im Maschinenbau	4	Deml	Schein			
			wählbare TL von HoC, ZAK bzw. Modulhand-buch	2	N.N.	Schein			
Bachelor-arbeit	Bachelorarbeit	15	Bachelorarbeit	12			PraA		30
			Präsentation	3					

Studienplan der Fakultät für Maschinenbau für den Bachelorstudiengang Maschinenbau gem. SPO 2015.
Gültig ab 01.10.2018, auf Beschlussfassung des Fakultätsrats vom 18.07.2018. Seite 4 von 7

1.3 Studienplan

Lehrveranstaltungen 1. bis 4. Semester Angaben in Semesterwochen-stunden (SWS)	WS 1. Sem.			SS 2. Sem.			WS 3. Sem.			SS 4. Sem.		
	V	Ü	P	V	Ü	P	V	Ü	P	V	Ü	P
Höhere Mathematik I-III	4	2		4	2		4	2				
Grundlagen der Fertigungstechnik	2											
Wellen- und Quantenphysik										2	1	
Technische Mechanik I-IV	3	2		3	2		2	2		2	2	
Werkstoffkunde I, II	4	1		3	1							
Werkstoffkunde-Praktikum[1]						2						
Technische Thermodynamik und Wärmeübertragung I, II							4	2		3	2	
Maschinenkonstruktionslehre I-IV	2	1		2	2		2	2	1	2	2	1
Informatik im Maschinenbau				2	2	2						
Elektrotechnik und Elektronik							4	2				
Strömungslehre I										2	1	
Arbeitstechniken Maschinenbau										1		1

Lehrveranstaltungen 5. bis 6. Semester Angaben in Semesterwochen-stunden (SWS)	WS 5. Sem.			SS 6. Sem.		
	V	Ü	P	V	Ü	P
Grundlagen der Mess- und Regelungstechnik	3	1				
Strömungslehre II	2	1				
Maschinen und Prozesse	4		1			
Betriebliche Produktionswirtschaft	3	1				
Schlüsselqualifikationen				2		
Wahlpflichtmodul	(2)			2		
Schwerpunkt (6 SWS, variabel)	3	( )	( )	3	( )	( )

1.4 Bachelorarbeit

Das Modul Bachelorarbeit besteht aus einer schriftlichen Ausarbeitung (Bachelorarbeit, 12 LP) sowie einer mündlichen Präsentation (3 LP). Die Präsentation soll spätestens sechs Wochen nach Abgabe der Bachelorarbeit erfolgen. Die Präsentation soll ca. 20 Minuten dauern und wird anschließend mit dem anwesenden Fachpublikum diskutiert. Die Leistung im Rahmen der Präsentation und der fachlichen Diskussion wird benotet und geht gemäß den Leistungspunkten in die Gesamtnote des Moduls Bachelorarbeit ein.
Die Durchführung und Benotung der Bachelorarbeit ist in § 14 der SPO für den Bachelorstudiengang Maschinenbau sowie im Modulhandbuch unter „Modul Bachelorarbeit" geregelt.

[1] Das Werkstoffkunde-Praktikum findet in der vorlesungsfreien Zeit zwischen SS und WS statt und beansprucht eine Woche.

2 Schwerpunkte

Folgende Schwerpunkte sind derzeit vom Fakultätsrat genehmigt (siehe Angaben im Modulhandbuch):

Schwerpunkt	Verantwortlicher	SP-Nr.
Antriebssysteme	Albers	2
Bahnsystemtechnik	Gratzfeld	50
Entwicklung und Konstruktion	Albers	10
Festigkeitslehre/Kontinuumsmechanik	Böhlke	13
Grundlagen der Energietechnik	Bauer	15
Informationsmanagement	Ovtcharova	17
Informationstechnik	Stiller	18
Kraftfahrzeugtechnik	Gauterin	12
Kraft- und Arbeitsmaschinen	Th. Koch	24
Materialwissenschaft und Werkstofftechnik	Heilmaier	26
Mechatronik	Hagenmeyer	31
Modellbildung und Simulation in der Dynamik	Seemann	61
Production Engineering	Lanza	52
Produktionssysteme	Schulze	38
Schwingungslehre	Fidlin	60
Technische Logistik	Furmans	44
Technik des Verbrennungsmotors	Th. Koch	57

Für den Schwerpunkt werden Teilleistungen im Umfang von 12 LP gewählt, davon werden mindestens 8 LP im Kernbereich (K) erworben. „KP“ bedeutet, dass die Teilleistung im Kernbereich Pflicht ist, sofern sie nicht bereits belegt wurde. Die übrigen 4 LP können aus dem Ergänzungsbereich kommen. Dabei dürfen im Rahmen von Praktika höchstens 4 LP erworben werden, die auch als unbenotete Modulleistung 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 Schwerpunkten besonders willkommen. Mit „EM“ gekennzeichnete Teilleistungen stehen im Bachelorstudiengang nicht zur Wahl. Für manche Schwerpunkte wird die Belegung einer bestimmten Teilleistung im Rahmen des Wahlpflichtmoduls empfohlen (s. Empfehlungen im Modulhandbuch).

Ein Absolvieren des Schwerpunktmoduls mit mehr als 12 LP ist nur im Fall, dass die Addition innerhalb des Schwerpunktmoduls nicht auf 12 LP aufgeht, erlaubt. Nicht zulässig ist es jedoch, noch weitere Teilleistungen anzumelden, wenn bereits 12 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 Prüfungsleistungen abgeschlossenen Teilleistungen. Dabei werden alle Teilleistungen gemäß ihrer LP gewichtet. Bei der Bildung der Gesamtnote wird der Schwerpunkt mit 12 LP gewertet.

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

3 Änderungshistorie (ab 20.07.2016)

20.07.2016	Sprachliche Anpassung an das Eckpunktepapier des KIT, Überarbeitung der Prüfungsmodalitäten
17.08.2016	Redaktionelle Änderungen, u.a. im Modul Physik
28.06.2017	Redaktionelle Änderungen, u.a. in den Modulen Technische Thermodynamik und Strömungslehre
13.07.2018	Anpassung der Schwerpunkte sowie redaktionelle Änderungen

2 Learning Outcomes

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

Through a research and practical orientation of the six-semester Bachelor's degree program for mechanical engineering at KIT, graduates of the program are prepared for lifelong learning and employment in typical professional fields of mechanical engineering in industry, services and public administration. They acquire the academic qualifications to pursue a master's degree program in mechanical engineering or related disciplines.

In the fundamental area of the studies, graduates acquire sound basic knowledge in engineering. With this in-depth knowledge of scientific theories, principles and methods, graduates can successfully deal with clearly specified problems that have a unique solution approach in mechanical engineering.

In the specialization area of the studies and in the thesis, cross-disciplinary problem-solving and synthesis skills for engineering systems are developed. Graduates are able to generate new solutions in the areas of their choice of engineering.

Graduates of the Bachelor's degree program in mechanical engineering at KIT can select basic methods in order to create models and compare them in familiar situations. They are able to take over and to work independently on preset problems and resulting tasks in organized teams, to integrate the results of others and to present and interpret their own results in written form. They can identify, analyze and develop systems and processes, and apply predefined assessment criteria, taking into account technical, economic and social constraints.

3 Modules

3.1 1st to 4th semester

Module: Advanced Mathematics [BSc-Modul 01, HM]

Coordination: A. Kirsch, T. Arens, F. Hettlich
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
21	Every term	3

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
0131000	Advanced Mathematics I (p. 66)	4	W	7	A. Kirsch, T. Arens, F. Hettlich
0180800	Advanced Mathematics II (p. 67)	4	S	7	A. Kirsch, T. Arens, F. Hettlich
0131400	Advanced Mathematics III (p. 68)	4	W	7	A. Kirsch, T. Arens, F. Hettlich

Learning Control / Examinations
written exam
The module grade will be computed by the grades of the lectures of the module weighted by credit points.

Conditions
None.

Learning Outcomes
The students know the basic facts and tools of one dimensional analysis. The students know the basics on vector spaces and multi-dimensional calculus and the basic techniques to solve differential equations. The students know techniques and applications of the multi-dimensional calculus (vector calculus) and have basic knowledge on partial differential equations and stochastics.

Content
Basic concepts, sequences and convergence, functions and continuity, series, differential calculus of one variable, integral calculus, vector spaces, differential equations, Laplace transform, vector-valued functions of several variables, applications of multi-dimensional calculus, domain integral, vector analysis, partial differential equations, Fourier theory, stochastics

Workload
lectures and exercises: 204h
homework and preparation of examination: 426h

Module: Engineering Mechanics [BSc-Modul 02, TM]

Coordination: T. Böhlke, W. Seemann
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
23	Every term	4

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2161245	Engineering Mechanics I (p. 103)	5	W	7	T. Böhlke, T. Langhoff
2162250	Engineering Mechanics II (p. 104)	5	S	6	T. Böhlke, T. Langhoff
2161203	Engineering Mechanics III (p. 105)	4	W	5	W. Seemann, Assistenten
2162231	Engineering Mechanics IV (p. 106)	4	S	5	W. Seemann, Assistenten

Learning Control / Examinations
prerequisite: attestation each semester by weekly homework assignments
”Engineering Mechanics I”, written, 90 minutes;
”Engineering Mechanics II”, written, 90 minutes;
”Engineering Mechanics III/IV”, written, 180 Minutes;

Conditions
None.

Learning Outcomes
After having finished the lectures EM I and EM II the students can

- assess stress and strain distributions for the basic load cases within the framework of thermoelasticity
- compute and evaluate 3D stress and strain states
- apply the principle of virtual displacements
- apply energy methods and eavaluate approximate solutions
- evaluate the stability of equilibrium positions
- list elastic-plastic material laws
- solve worksheet problems to topics of the lecture using the computer algebra system MAPLE

In EM III and EM IV the students learn to analyse the motion of points and systems. Based on the axioms of Newton and Euler they know how to derive equations of motion. Besides the synthetic methods they get familiar with analytical methods which are based on energy expressions and can be applied efficiently and formalised. These methods are introduced in the scope of systems of mechanical engineering so that students can determine and analyse motions and the forces which are generated by these motions.

Content
See detailed descriptions of the contents of the lectures “Engineering Mechanics I-IV”

Workload

Module: Manufacturing Processes [BSc-Modul 12, FertProz]

Coordination: V. Schulze, F. Zanger
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
4	Every 2nd term, Winter Term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2149658	Basics of Manufacturing Technology (p. 60)	2	W	4	V. Schulze, F. Zanger

Learning Control / Examinations
The assessment is carried out as a written exam (1 hour).

Conditions
none

Recommendations
none

Learning Outcomes
The students . . .

- are able to classify the manufacturing processes by their general functionality according to the specific main groups (DIN 8580).
- have the ability to declare and explain the function of the significant manufacturing processes of the main groups (DIN 8580).
- are enabled to describe the characteristic process features (geometry, materials, accuracy, tools, machines) of the significant manufacturing processes of the main groups (DIN 8580).
- have the ability to derive the relevant process specific technical advantages and disadvantages of the characteristic process features.
- are enabled to perform a selection of suitable manufacturing processes for given components.
- are enabled to classify the required manufacturing processes in the expiry of a process chain for the production of given sample products.

Content
The objective of the lecture is to classify the manufacturing technology within the wider context of production engineering, to provide an overview of the different manufacturing processes and to establish basic process knowledge of the common processes. The lecture conveys the basic principles of manufacturing technology and deals with the manufacturing processes based on example components 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 following topics will be covered:

- Primary processing (casting, plastics engineering, sintering, additive manufacturing processes)
- Forming (sheet-metal forming, massive forming)
- Cutting (machining with geometrically defined and geometrically undefined cutting edges, separating, abrading)

- Joining
- Coating
- Heat treatment and surface treatment

Workload
regular attendance: 21 hours
self-study: 99 hours

Module: Mechanical Design [BSc-Modul 10, MKL (2016)]

Coordination: A. Albers, S. Matthiesen
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
20	Every term	4

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2145178	Mechanical Design I (p. 73)	3	W	3	A. Albers, S. Matthiesen
2146178	Mechanical Design II (p. 77)	4	S	4	A. Albers, S. Matthiesen
2145151	Mechanical Design III (p. 78)	4	W	5	A. Albers, S. Matthiesen
2146177	Mechanical Design IV (p. 80)	3	S	8	A. Albers, S. Matthiesen

Learning Control / Examinations
After Mechanical Design I and II:
Written Examination concerning the teaching program of mechanical design I and II: duration 60 min
After Mechanical Design III and IV:
Examination concerning the teaching programm of mechanical design III and IV with

- written part duration 60 min and
- design part duration 180 min.

Conditions
none

Learning Outcomes
The students are able to ...

- analyze the function of unknown machine elements.
- use the interpretation and dimensioning guidelines according to the common standardization regulations.
- identify technical problems and to work out and evaluate systematic solutions.
- illustrate problem solutions in technical drawings and cad models according to the common standardization regulations.
- estimate the volume and time need of the given tasks and to split them between the team members.
- synthesize the design steps of product engineering by means of a complex technical system.

Content
See detailed descriptions of the lectures mechanical design I-IV.

Workload
according to the single module components

Module: Materials Science and Engineering [BSc-Modul 03, WK]

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

ECTS Credits	Cycle	Duration
14	Every 2nd term, Winter Term	2

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2173550	Materials Science I (p. 113)	5	W	7	H. Seifert, S. Ulrich, M. Heilmaier, A. Pundt
2174560	Materials Science II for mach, IP-M, phys (p. 114)	4	S	4	M. Heilmaier, H. Seifert, S. Ulrich, A. Pundt
2174597	Experimental Lab Course in Materials Science (p. 55)	2	S	3	K. Weidenmann, M. Heilmaier

Learning Control / Examinations
not graded: participation in 10 lab experiments, introductory colloquia must be passed and 1 short presentation must be presented. The lab course must be finished successfully prior to the registration for the oral exam;
graded: oral exam covering the whole module, about 25 minutes.

Conditions
none

Learning Outcomes
Within this Module the students should

- gain knowledge of basics about structural and functional materials
- be able to draw relationships between atomic structure, microstructure and properties
- be able to apply appropriate methods to determine mechanical and other relevant properties as well as to characterize the microstructure of materials
- be able to assess material properties and corresponding applications

Content
WK I
Structure of atoms and atomic bonding
Crystalline solids
Defects in crystalline solids
Amorphous and partially crystalline solids
Constitution of alloys and materials
Diffusion and phase transformation in the solid state
Microscopic characterization method
Characterization with X-Rays and neutrons
Non-destructive Testing
Mechanical Testing
WK II
Iron based alloys
Non-iron based alloys
Ceramics
Glases
Polymers

Composite Materials

Workload
The work load of the module is about 420 hours.
The workload for the lab course Materials Science is 90 h in total and consists of the presence during the 10 experiments (one week half-time, 4 hours per day) as well as preparation and rework time at home.
The workload for the lecture Materials Science I & II is 165 h per semester and consists of the presence during the lectures (WS: 4 SWS, SS: 2SWS) and the exercises (1 SWS per WS and 1 SWS per SS) as well as preparation and rework time at home.

Module: Production Operations Management [BSc-Modul 13, BPW]

Coordination: K. Furmans
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
5	Every 2nd term, Winter Term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2110085	Production Operations Management (p. 46)	2	W	3	K. Furmans, G. Lanza
2110086	Production Operations Management-Project (p. 47)	2	W	2	G. Lanza, K. Furmans

Learning Control / Examinations
The success control takes place in the form of partial examinations in the individual courses of the module. These are a written exam (duration: 90 minutes) and a different type of examination. The module grade is made up of the grades of the courses in the module weighted by credit points.

Conditions
none

Recommendations
none

Learning Outcomes
If you successfully passed this course you will be able to:

- state the relevant technical terms of business administration, logistics and production engineering
- describe the interrelation between these technical terms
- describe the most important decision problems qualitatively and quantitatively
- apply the appropriate decision models to solve the respective decision problems
- critically evaluate the results and draw appropriate conclusions
- extend the learned methods and models by researching on you own

Content
The lecture covers the basics of operations and supply chain management as well as business management basics in accounting, investment calculation and legal forms.

Workload
regular attendance: 42 hours,
self-study: 108 hours

Remarks
It is a joint lecture of the Institute of Materials Handling and Logistics (IFL) and the Institute of Production Science (WBK). The institutes alternate with each cycle.

Module: Engineering Thermodynamics [BSc-Modul 04, TTD]

Coordination: U. Maas
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
15	Every term	2

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2165501	Technical Thermodynamics and Heat Transfer I (p. 108)	5	W	8	U. Maas
2166526	Technical Thermodynamics and Heat Transfer II (p. 109)	5	S	7	U. Maas

Learning Control / Examinations
written exam, graded

Conditions
Prerequisite: attestation each semester by weekly homework assignments

Learning Outcomes
The students acquire the competency to master the fundamentals of thermodynamics and the ability to apply the knowledge an problem-solving in various branches of mechanical engineering and especially in the Energy Technology sector.
An integral part of the model is that students can define the fundamental laws of thermodynamics and their application. The students are competent in describing and comparing the main processes in energy conversion. Using tools also applied in Industry they are capable of analysing and rating the efficiency of processes. The students are capable of discussing the thermodynamical correlation of ideal gas mixtures, real gases and of humid air as well analysing them with the help of the laws of thermodynamic. Furthermore the students are capable of defining and applying the heattransfer mechanisms.

Content
Cf. detailed description of the contents of the lectures in “Engineering Thermodynamics and Heat Transfer I and II”.

Workload

Module: Mechanics of Fluids [BSc-Modul 05, SL (2016)]

Coordination: B. Frohnapfel
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
8		2

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2154512	Fluid Mechanics I (p. 98)	3	S	4	B. Frohnapfel
2153512	Fluid Mechanics II (p. 99)	3	W	4	B. Frohnapfel

Learning Control / Examinations
Common examination of “Fluid Mechanics I” and “Fluid Mechanics II”; written exam, 3 hours (graded)

Conditions
None.

Learning Outcomes
After having completed this module the student is capable of deriving the mathematical equations that describe the motion of fluids and can determine flow quantities for generic problems. He/she can name characteristic properties of fluids and distinguish different flow states. The student is capable of determining fluid quantities in fundamental applications. This includes the calculation of

- static and dynamic forces acting from the fluid onto the solid
- two-dimensional viscous flows
- one-dimensional incompressible and compressible flows without losses
- lossy flows through pipes

Content
see detailled description of the lecture “Mechanics of Fluids I” and “Mechanics of Fluids II”

Workload

Module: Physics [BSc-Modul 06, Ph (2016)]

Coordination: B. Pilawa, Gernot Goll
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
5	Every 2nd term, Summer Term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2400412	Wave and Quantum Physics (p. 112)	3	S	5	B. Pilawa

Learning Control / Examinations
written exam

Conditions
None.

Learning Outcomes
The students

- are familiar with the properties of waves and can discuss those
- can reflect on the principles of relativity
- comprehend the coherence of the particle and wave description of light and matter
- can explain the limits of wave physics
- are able the apply the Schrödinger-equation to basic problems in quantum mechanics
- can explain the basic properties of atoms, especially for the hydrogen atom
- can discuss fundamental aspects of the electronic properties of solids

Content

- Properties of waves
- Acoustic and electromagnetic waves
- Interference and diffraction
- Relativity
- Wave-particle dualism
- Basic properties of atoms
- Basic electronic properties of solids

Workload
lectures and exercises: 40h
homework and preparation of examination: 110h

Module: Electrical Engineering [BSc-Modul 07, ET]

Coordination: K. Becker
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
8	Every 2nd term, Winter Term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
23339	Electrical Engineering and Electronics for Mechanical Engineers (p. 54)	6	W	8	K. Becker

Learning Control / Examinations
graded, written exam, 180 minutes.

Conditions
None

Learning Outcomes
The students have an overview of the physical basics of electrical engineering (electrical field, magnetic field, resistor, capacitor, inductor), know methods for the calculation of electrical DC- and AC-circuits, and understand the construction and steady-state performance of the basic electrical machines (transformer, DC-, induction- and synchronous machine).
The students have an overview of the most important semicon-ductor devices and their functionality, understand the basic principles of power electronic circuits and their arrangements to more complex structures (for semiconductor devices which can be switched off or can not be switched off as well), and know the basics of the operation mode of operational amplifiers.

Content
Fundamental terms, ohmic resistor, electrical field, magnetic field, oscillations, complex calculation of alternating current circuits, three phase current, measurement technique, drive engineering, DC machine, transformer, induction machine, synchronous machine, semiconductor devices, transistors and thyristors, power electronics, operational amplifiers

Workload
Lectures and exercises: 60 h
Homework and preparation of examination: 180 h

Module: Computer Science [BSc-Modul 09, Inf]

Coordination: J. Ovtcharova
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
6	Every 2nd term, Summer Term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2121390	Computer Science for Engineers (p. 69)	4	S	6	J. Ovtcharova

Learning Control / Examinations
graded, written: “Science for Engineers”, 100%, 180 minutes

Conditions
Prerequisite: Computer Lab Certificate

Recommendations
None.

Learning Outcomes
Students can identify and explain fundamental terms, problems and concepts of computer science. They can apply the basic methods of the OO modeling with UML and implement the object-oriented programming (OOP) with the programming language JAVA.

Content
Basics: Information representation- and processing, terms and definitions: alphabet, data, signals, information, numeral systems, propositional logic and Boolean algebra, computer architectures, programming paradigms.
Object Orientation: Definition and important characteristics of object orientation, Object-oriented modeling with UML.
Data Structures: Definition, properties and application of graphs, trees, linked lists, queues and stacks.
Algorithms: Characteristics of algorithms, complexity analysis, design methods, important examples.
Database management systems: Relational data model, relational algebra, declarative language SQL.
Basics and concepts of JAVA. Introduction to programming using JAVA.

Workload
regular attendance: 63 hours
self-study: 120 hours

Remarks
None.

Module: Soft Skills [BSc-Modul 16, SQL (2016)]

Coordination: B. Deml
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
6	Every 2nd term, Summer Term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2174970	Working Methods in Mechanical Engineering (p. 43)	1	S	2	B. Deml
2149661	Value stream within enterprises – The value chain at Bosch (p. 50)	2	W	2	J. Fleischer, Dr. Rudolf Maier
2110968	Workshop 'Working Methods in Mechanical Engineering' (IFAB) (p. 133)	1	S	2	B. Deml
2162994	Workshop 'Working Methods for Mechanical Engineering' (ITM, Proppe) (p. 146)	1	S	2	C. Proppe
2118973	Workshop 'Working Methods in Mechanical Engineering' (IFL) (p. 135)	1	S	2	M. Mittwollen, S. Bolender
2142975	Workshop 'Working Methods in Mechanical Engineering' (IMT) (p. 139)	1	S	2	M. Worgull
2162983	Workshop 'Working Methods in Mechanical Engineering' (ITM, Böhlke) (p. 144)	1	S	2	T. Böhlke, Mitarbeiter
2178981	Workshop 'Working Methods in Mechanical Engineering' (IAM-WBM) (p. 130)	1	S	2	O. Kraft, P. Gruber
2182974	Workshop 'Working Methods in Mechanical Engineering' (IAM-CMS, Gumbsch) (p. 125)	1	S	2	P. Gumbsch, J. Gagel, K. Schulz
2106984	Workshop 'Working Methods in Mechanical Engineering' (AIA) (p. 117)	1	S	2	M. Lorch
2114450	Workshop 'Working Methods in Mechanical Engineering' (FAST - Leichtbautechnologie) (p. 120)	1	S	2	F. Henning
2114979	Workshop 'Working Methods in Mechanical Engineering' (FAST - MOBIMA) (p. 121)	1	S	2	M. Geimer
2114989	Workshop 'Working Methods in Mechanical Engineering' (FAST - Fahrzeugtechnik) (p. 119)	1	S	2	F. Gauterin, Gießler, Unrau
2114990	Workshop 'Working Methods in Mechanical Engineering' (FAST - Bahnsystemtechnik) (p. 118)	1	S	2	P. Gratzfeld
2126980	Workshop 'Working Methods in Mechanical Engineering' (IAM-KWT) (p. 129)	1	S	2	M. Hoffmann
2128998	Workshop 'Working Methods in Mechanical Engineering' (IMI) (p. 138)	1	S	2	J. Ovtcharova, Mitarbeiter
2134996	Workshop 'Working Methods in Mechanical Engineering' (IFKM) (p. 134)	1	S	2	T. Koch

2138997	Workshop 'Working Methods in Mechanical Engineering' (MRT) (p. 151)	1	S	2	C. Stiller
2146971	Workshop 'Working Methods in Mechanical Engineering' (IPEK, Albers) (p. 141)	1	S	2	A. Albers
2146972	Workshop 'Working Methods in Mechanical Engineering' (IPEK, Matthiesen) (p. 142)	1	S	2	S. Matthiesen
2150987	Workshop 'Working Methods in Mechanical Engineering' (WBK, Schulze) (p. 154)	1	S	2	V. Schulze
2150988	Workshop 'Working Methods in Mechanical Engineering' (WBK, Lanza) (p. 153)	1	S	2	G. Lanza
2150989	Workshop 'Working Methods in Mechanical Engineering' (WBK, Fleischer) (p. 152)	1	S	2	J. Fleischer
2158978	Workshop 'Working Methods in Mechanical Engineering' (FSM) (p. 122)	1	S	2	M. Gabi
2162995	Workshop 'Working Methods in Mechanical Engineering' (ITM, Fidlin) (p. 145)	1	S	2	A. Fidlin
2166991	Workshop 'Working Methods in Mechanical Engineering' (ITT) (p. 149)	1	S	2	U. Maas
2170972	Workshop 'Working Methods in Mechanical Engineering' (ITS) (p. 148)	1	S	2	H. Bauer
2174976	Workshop 'Working Methods in Mechanical Engineering' (IAM-WK, Elsner) (p. 131)	1	S	2	P. Elsner
2174986	Workshop 'Working Methods in Mechanical Engineering' (IAM-WK, Heilmaier) (p. 132)	1	S	2	M. Heilmaier, K. von Klinski-Wetzel
2174987	Workshop 'Working Methods in Mechanical Engineering' (IAM-AWP) (p. 124)	1	S	2	H. Seifert, P. Smyrek , M. Rank, P. Franke
2182982	Workshop 'Working Methods in Mechanical Engineering' (IAM-CMS, Nestler) (p. 127)	1	S	2	B. Nestler, A. August
2190497	Workshop 'Working Methods in Mechanical Engineering' I (IFRT, Stieglitz) (p. 137)	1	S	2	V. Sánchez-Espinoza
2190975	Workshop 'Working Methods in Mechanical Engineering' (IFRT, Cheng) (p. 136)	1	S	2	X. Cheng
2154992	(p. 143)	1	S	2	B. Frohnapfel
2162996	Workshop 'Working Methods in Mechanical Engineering' (ITM, Seemann) (p. 147)	1	S	2	W. Seemann

Learning Control / Examinations

- Attendance is compulsory and active participation at all sessions of the offered workshops
- Certifications of the topics of the online lecture within the workshop sessions
- Workshop tasks must be treated completely
- HoC and ZAK (Centre for Cultural and General Studies) event(s) of 2 CP or (alternatively) a lecture of the Department of Mechanical Engineering approved by the Examination Committee

Conditions
None.

Learning Outcomes
After completing this module, the students are able

1. to identify and coordinate goals and the resulting working tasks, to apply a systematic and goal-oriented approach, to set priorities and to evaluate the feasibility of a task,
2. to describe and to apply goal- and resource-oriented methods for the planning of a working task under defined conditions,
3. to describe and apply methods for scientific research and the selection of relevant information according to defined criteria of quality,
4. to evaluate the quality of a scientific source,
5. to describe and apply empirical methods in mechanical engineering,
6. to document scientific information in a clear, structured and convincing style in different formats (e. g. poster, expose, abstract, bachelor thesis) and to visualise this information appropriately (e. g. by construction diagrams, flow diagrams),
7. to evaluate the quality of a scientific text or poster,
8. to present scientific information in a convincing and appealing style,
9. to work in a heterogeneous team, to solve conflicts and to resume responsibility for themselves and others,
10. to communicate in an objective way within a team, to achieve own interests, to describe the interests of others in own words and to moderate a discussion.

Content
see submodule descriptions

Workload
The work load accounts for 180 hours, which corresponds to 6 credit points.

3.2 5th to 6th semester

Module: Machines and Processes [BSc-Modul 11, MuP]

Coordination: H. Kubach
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
7	Every term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2185000	Machines and Processes (p. 71)	4	W	7	H. Kubach, M. Gabi, H. Bauer, U. Maas

Learning Control / Examinations
written exam and successful lab course

Conditions
Successful lab course is a precondition to take part at the exam.

Learning Outcomes
The students can name and describe basic energy conversion processes and energy converting machines. They can explain the application of these energy conversion processes in various machines. They can analyze and evaluate the processes and machines in terms of functionality and efficiency and they are able to solve basic technical problems in terms of operating the machines.

Content
basics of thermodynamics
thermal fluid machines

- steam turbunes
- gas turbines
- combined-cycle plants
- turbines and compressors
- aircraft engines

hydraulic fluid machines

- oerating performance
- characterization
- control
- cavitation
- wind turbines, propellers

internal combustion engines

- characteristic parameters
- engine parts
- kinematics

- engine processes
- emissions

Workload
regular attendance: 48 hours
self-study: 160 hours

Remarks
Lab course and lecture take place in summer and winter semester.
In the summer term the lecture is held in English. The lab course is always bilingual.

Module: Measurement and Control Systems [BSc-Modul 08, MRT]

Coordination: C. Stiller
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
7	Every 2nd term, Winter Term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2137301	Measurement and Control Systems (p. 63)	3	W	7	C. Stiller

Learning Control / Examinations
graded written exam

Conditions
None.

Learning Outcomes

- Students are able to name, describe and explain control principles applied to physical quantities.
- They are able to name, analyze and assess system theoretic characteristics of dynamical systems.
- Students are able to represent real systems in a system theoretic model and to assess the suitability of a given model.
- Students are able to apply methods for controller design and to analyze their properties.
- Students are able to select appropriate principles of metrology and to model, analyze and assess measurement setups.
- Students are able to quantify and assess measurement uncertainties.

Content

Workload

Module: Major Field [BSc-Modul 14, SP]

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

ECTS Credits	Cycle	Duration
12	Every term	2

Learning Control / Examinations
oral exam

Conditions
None.

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

Content
see chosen major field

Workload
The work load is about 360 hours, corresponding to 12 credit points.

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

Module: Compulsory Elective Course (BSc) [BSc-Modul 15, WPM]

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

ECTS Credits	Cycle	Duration
4	Every term	1

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2147175	CAE-Workshop (p. 48)	3	W/S	4	A. Albers, Assistenten
2105011	Introduction into Mechatronics (p. 51)	3	W	6	M. Reischl, M. Lorch
2162235	Introduction into the multi-body dynamics (p. 52)	3	S	5	W. Seemann
2114093	Fluid Technology (p. 58)	4	W	5	M. Geimer, M. Scherer, L. Brinkschulte
2117095	Basics of Technical Logistics (p. 64)	4	W	6	M. Mittwollen, J. Oellerich
2165515	Fundamentals of Combustion I (p. 65)	2	W	4	U. Maas
2161224	Machine Dynamics (p. 72)	3	S	5	C. Proppe
2161230	Mathématiques appliquées aux sciences de l'ingénieur (p. 84)	2	W/S	5	J. Dantan
2161206	Mathematical Methods in Dynamics (p. 85)	2	W	5	C. Proppe
2161254	Mathematical Methods in Strength of Materials (p. 86)	3	W	5	T. Böhlke
2162241	Mathematical methods of vibration theory (p. 87)	3	S	5	W. Seemann
2154432	Mathematical Methods in Fluid Mechanics (p. 88)	3	S	6	B. Frohnapfel, D. Gatti
2183702	Modelling of Microstructures (p. 89)	3	W	5	A. August, B. Nestler, D. Weygand
2183703	Numerical methods and simulation techniques (p. 90)	3	W/S	5	B. Nestler
4040311	Modern Physics for Engineers (p. 91)	2	S	5	B. Pilawa
2142890	Physics for Engineers (p. 92)	2	S	4	P. Gumbsch, A. Nesterov-Müller, D. Weygand, T. Förtsch
2181612	Physical basics of laser technology (p. 93)	3	W	4	J. Schneider
2121350	Product Lifecycle Management (p. 94)	3	W	4	J. Ovtcharova, T. Maier
2174576	Systematic Materials Selection (p. 100)	3	S	5	S. Dietrich
2133123	Fundamentals of Combustion Engine Technology (p. 101)	2	W	5	S. Bernhardt, H. Kubach, J. Pfeil, O. Toedter, U. Wagner, A. Velji
2121001	Integrated Information Systems for engineers (p. 102)	3	S	4	J. Ovtcharova
2161212	Vibration Theory (p. 107)	3	W	5	A. Fidlin
3122031	Virtual Engineering (Specific Topics) (p. 45)	2	S	4	J. Ovtcharova

2165512	Heat and Mass Transfer (p. 111)	2	W	4	U. Maas
2181738	Scientific computing for Engineers (p. 115)	2	W	4	D. Weygand, P. Gumbsch

Learning Control / Examinations
oral exam

Conditions
None

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

Content
see chosen compulsory elective subject

Workload
The work load varies from lecture to lecture, for example a lecture consisting of 2 SWS includes 28 h of presence during the lecture and 92 h preparation and rework time at home, 120 hours in total.

Remarks
None.

Module: Bachelor Thesis [BSc-2015_AA]

Coordination: P. Gratzfeld, M. Heilmaier
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration
15	Every term	1

Learning Control / Examinations
The module Bachelor Thesis consists of a written bachelor thesis and an oral presentation of a scientific subject chosen by the student himself/herself or given by the supervisor. The bachelor'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 bachelor thesis corresponds to 12 ECTS. The maximal processing time of the bachelor thesis takes three months. The examination board defines the languages the thesis has to be written in. 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 bachelor 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 bachelor thesis is not completed in time, this examination is "failed" (5,0), unless the student is not responsible. The bachelor 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 bachelor thesis is graded by the examination board within this assessment; another expert can be appointed too. The bachelor 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 bachelor 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 bachelor module in accordance with the weighted credit points (3LP).
The learning control is described in detail in § 14 SPO.

Conditions
Voraussetzung für die Zulassung zum Modul Bachelorarbeit ist, dass die/der Studierende Modulprüfungen im Umfang von 120 LP erfolgreich abgelegt hat. Über Ausnahmen entscheidet der Prüfungsausschuss auf Antrag der/des Studierenden (vgl. §14 (1) der 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, 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 a question, is able to choose scientific methods and techniques, and use them to solve the question or to identify other potentials. In general, 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. He/she is able to clearly structure a scientific work and (a) to communicate it in written form using 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 bachelor's thesis. The topic is set by the supervisor of the thesis in accordance with § 14 (3) SPO.

Workload
The workload for the preparation and presentation of the bachelor's thesis is about 450 hours.

4 Courses

4.1 All Courses

Course: Working Methods in Mechanical Engineering [2110969]

Coordinators: B. Deml
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.Sc.)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	en

Learning Control / Examinations
Tests within the workshop sessions concerning the topics of the online-lecture as well as active participation during all four workshop sessions.

Conditions
None.

Learning Outcomes
By the end of the lecture, the participants have obtained core working techniques, which form an important basis for the scientific work as a Mechanical Engineer and which enable the participants to write their degree theses self-dependently:
The students are able to complete a sound scientific literature research and to acquire scholarly literature or information on their own. Besides, they know techniques that make it easier for them to get into the scientific writing process and they are aware of formal aspects (e. g. citation rules, plagiarism) that have to be considered when writing a scientific work. Further on the students know, which aspects are to be considered in order to give a convincing scientific presentation.
Finally, on completion of the course, they know essential techniques in the field of self- and time-management as well as social-psychological principles of team-work.

Content

1. Time and self-management
   - Time planning – from the semester outline to a day's schedule
   - Time planning – Why should I set priorities?
   - The Eisenhower-principle – How do I set priorities?
   - Definition of goals – How do I set realistic learning goals?
   - Low motivation – What to do by a lack of motivation?
   - Organization of breaks – How do I optimize my learning result by breaks?
   - Design of learning place – Where and how do I learn in a right way?
2. Literature research
   - Principles of literature research
   - Research preparation
   - Literature research in KIT-catalogue
   - Literature research in specialist databases
   - Literature research in the internet
   - Literature procurement
3. Team work
   - Team phases
   - Team meetings
   - Team roles

- Group performance
- Communication
- Finishing teamwork productively

4. Scientific writing
    - Process of writing: in five steps from the idea to the text
    - Structure of a scientific work
    - To get into writing
    - Tips for formulating a scientific work
    - Plagiarism and how it is avoided
    - Citing, referring, listing: Reference techniques in scientific works
    - Keeping information from lectures and texts
    - Laboratory journal: documenting experiments in a systematic manner
5. Scientific presentation
    - Reception and overview
    - Focussing
    - Structuring
    - Formulating
    - Visualizing
    - Editing
    - Presenting

Media
The lecture is organized as an e-learning programme, which is enhanced by one classroom-based sessions at the beginning of the semester. The online-lecture as well as further information are available in ILIAS.

Course: Working Methods in Mechanical Engineering [2174970]

Coordinators: B. Deml
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
By the end of the lecture, the participants have obtained core working techniques, which form an important basis for the scientific work as a Mechanical Engineer and which enable the participants to write their degree theses self-dependently:
The students are able to complete a sound scientific literature research and to acquire scholarly literature or information on their own. Besides, they know techniques that make it easier for them to get into the scientific writing process and they are aware of formal aspects (e. g. citation rules, plagiarism) that have to be considered when writing a scientific work. Further on the students know, which aspects are to be considered in order to give a convincing scientific presentation.
Finally, on completion of the course, they know essential techniques in the field of self- and time-management as well as social-psychological principles of team-work.

Content

1. Time and self-management
    - Time planning – from the semester outline to a day's schedule
    - Time planning – Why should I set priorities?
    - The Eisenhower-principle – How do I set priorities?
    - Definition of goals – How do I set realistic learning goals?
    - Low motivation – What to do by a lack of motivation?
    - Organization of breaks – How do I optimize my learning result by breaks?
    - Design of learning place – Where and how do I learn in a right way?
2. Literature research
    - Principles of literature research
    - Research preparation
    - Literature research in KIT-catalogue
    - Literature research in specialist databases
    - Literature research in the internet
    - Literature procurement
3. Team work
    - Team phases
    - Team meetings
    - Team roles
    - Group performance
    - Communication
    - Finishing teamwork productively

4. Scientific writing
    - Process of writing: in five steps from the idea to the text
    - Structure of a scientific work
    - To get into writing
    - Tips for formulating a scientific work
    - Plagiarism and how it is avoided
    - Citing, referring, listing: Reference techniques in scientific works
    - Keeping information from lectures and texts
    - Laboratory journal: documenting experiments in a systematic manner
5. Scientific presentation
    - Reception and overview
    - Focussing
    - Structuring
    - Formulating
    - Visualizing
    - Editing
    - Presenting

Media
The lecture is organized as an e-learning programme, which is enhanced by one classroom-based sessions at the beginning of the semester. The online-lecture as well as further information are available in ILIAS.

Course: Virtual Engineering (Specific Topics) [3122031]

Coordinators: J. Ovtcharova
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Production Operations Management [2110085]

Coordinators: K. Furmans, G. Lanza
Part of the modules: Production Operations Management (p. 25)[BSc-Modul 13, BPW]

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

Learning Control / Examinations
The assessment consists of a 90 minutes written examination (according to §4(2), 1 of the examination regulation).

Conditions
Production Operations Management-Project (2110086) must have been completed successfully.

Recommendations
None

Learning Outcomes
If you successfully passed this course you will be able to:

- state the relevant technical terms of business administration, logistics and production engineering
- describe the interrelation between these technical terms
- describe the most important decision problems qualitatively and quantitatively
- apply the appropriate decision models to solve the respective decision problems
- critically evaluate the results and draw appropriate conclusions
- extend the learned methods and models by researching on you own

Content
The lecture covers the basics of operations and supply chain management as well as business management basics in accounting, investment calculation and legal forms.

Media
Materials for the lecture are provided by Ilias (https://ilias.studium.kit.edu/).

Literature
F. Robert Jacobs, Richard B. Chase (2014): Operations and supply chain management

Remarks
It is a joint lecture of the Institute of Materials Handling and Logistics (IFL) and the Institute of Production Science (WBK). The institutes alternate with each cycle.

Course: Production Operations Management-Project [2110086]

Coordinators: G. Lanza, K. Furmans
Part of the modules: Production Operations Management (p. 25)[BSc-Modul 13, BPW]

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

Learning Control / Examinations
Assignments during the semester consisting of solving 5 and presenting 2 case studies. The grade consists of:

- 80% assessment of the case study as group work
- 20% oral examination during case study colloquiums

A detailed description of the learning control can be found under Content.

Conditions
None

Recommendations
None

Learning Outcomes
If you successfully passed this course you will be able to:

- state the relevant technical terms of business administration, logistics and production engineering
- describe the interrelation between these technical terms
- describe the most important decision problems qualitatively and quantitatively
- apply the appropriate decision models to solve the respective decision problems
- critically evaluate the results and draw appropriate conclusions
- extend the learned methods and models by researching on you own

Content
Students are divided into groups for this course. Five case studies will be carried out in these groups. The results of the group work will be presented and evaluated in writing. In addition, selected groups will present and defend their results. In the defenses, the understanding of the models dealt with in the course is also tested.
The participation of all members of the selected groups in the oral defenses is compulsory and will be controlled. Four written submissions must be passed. The grade will consist of the best four out of five. For the written submission the group receives a common grade, in the defense each group member is evaluated individually. The defenses are fully included in the grade, but they do not have to be passed in order to pass the entire event. The final score of the event consists of 80% of the written submissions and 20% of the defense evaluation.

Media
Materials for the lecture are provided by Ilias (https://ilias.studium.kit.edu/).

Literature
F. Robert Jacobs, Richard B. Chase (2014): Operations and supply chain management

Remarks
It is a joint lecture of the Institute of Materials Handling and Logistics (IFL) and the Institute of Production Science (WBK). The institutes alternate with each cycle.

Course: CAE-Workshop [2147175]

Coordinators: A. Albers, Assistenten
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: A holistic approach to power plant management [2189404]

Coordinators: M. Seidl, R. Stieglitz
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.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: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

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: Introduction into Mechatronics [2105011]

Coordinators: M. Reischl, M. Lorch
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Electromagnetics and Numerical Calculation of Fields [23263]

Coordinators: O. Dössel
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.Sc.)]

ECTS Credits	Hours per week	Term	Instruction language
4,5	3	Winter term	en

Learning Control / Examinations
Written Exam

Conditions
None.

Recommendations
Fundamentals of Electromagnetic Field Theory

Learning Outcomes
This course is an introduction to modern methods of numerical field calculation
The course starts with a revision of Maxwell equations and the most important methods of analytical field calculation. Then the most important methods of numerical field calculation are presented.

Content
Maxwell's equations, materials equations, boundary conditions, fields in ferroelectric and ferromagnetic materials
electric potentials, electric dipole, Coulomb integral, Laplace and Poisson's equation, separation of variables in cartesian, cylindrical and spherical coordinates
Dirichlet Problem, Neumann Problem, Greens function,
Field energy density and Poynting vector,
electrostatic field energy, coefficients of capacitance
vector potential, Coulomb gauge, Biot-Savart-law
magnetic field energy, coefficients of inductance
magnetic flux and coefficients of mutual inductance,
fields problems in steady electric currents,
law of induction, displacement current
general wave equation for E and H, Helmholtz equation
skin effect, penetration depth, eddy currents
retarded potentials, Coulomb integral with retarded potentials
wave equation for ϕ and A, Lorentz gauge, plane waves
Hertzian dipole, near field solution, far field solution
transmission lines, fields in coaxial transmission lines
waveguides, TM-waves, TE-waves
finite difference method FDM
finite difference - time domain FDTD, Yee´s algorithm
finite difference - frequency domain
finite integration method FIM
finite element method FEM
boundary element method BEM
solving large systems of linear equations
basic rules for good numerical field calculation

Literature
Recommendation of several books, Figures of the lecture

Remarks
Current information can be found on the ITIV (http://www.ibt.kit.edu/) webpage and within the eStudium-teachingplatform (www.estudium.org).

Course: Electrical Engineering and Electronics for Mechanical Engineers [23339]

Coordinators: K. Becker
Part of the modules: Electrical Engineering (p. 29)[BSc-Modul 07, ET]

ECTS Credits	Hours per week	Term	Instruction language
8	6	Winter term	de

Learning Control / Examinations
written examination with duration of 3h

Conditions
none

Learning Outcomes
The students have an overview of the physical basics of electrical engineering (electrical field, magnetic field, resistor, capacitor, inductor), know methods for the calculation of electrical DC- and AC-circuits, and understand the construction and steady-state performance of the basic electrical machines (transformer, DC-, induction- and synchronous machine).
The students have an overview of the most important semicon-ductor devices and their functionality, understand the basic principles of power electronic circuits and their arrangements to more complex structures (for semiconductor devices which can be switched off or can not be switched off as well), and know the basics of the operation mode of operational amplifiers.

Content
Fundamental terms, ohmic resistor, electrical field, magnetic field, oscillations, complex calculation of alternating current circuits, three phase current, measurement technique, drive engineering, DC machine, transformer, induction machine, synchronous machine, semiconductor devices, transistors and thyristors, power electronics, operational amplifiers

Literature
see homepage
download:
script (ca. 600 pages)
powerpoint sheets

Course: Experimental Lab Course in Materials Science [2174597]

Coordinators: K. Weidenmann, M. Heilmaier
Part of the modules: Materials Science and Engineering (p. 23)[BSc-Modul 03, WK]

ECTS Credits	Hours per week	Term	Instruction language
3	2	Summer term	

Learning Control / Examinations
Oral colloquium at the beginning of each topic; certificate of successful attendance.

Conditions
none

Learning Outcomes
The students are able to describe the relationship between atomic structure, microscopical observations, and properties of solid materials.

The students can name standard materials characterization methods and can describe the execution of the tests as well as the evaluation of the results. The students are able to asses materials on base of the data obtained by these methods.
The students are capable to select appropriate experiments to clarify probelms regarding the materials behaviour. They can describe the experimental procedures and can carry out experiments. They can derive material properties from data gained in experiments. They can interpret these properties regarding microstructure-propety-relations.

Content
Performing and evaluating of two laboratory experiments in each of the following topics:

Mechanical testing of materials
Nonmetallic materials
Microstructure and properties
Cyclic loading / fatigue
Influence of manufacturing technique on materials

Literature
Laboratory script;

Shackelford, J.F.
Werkstofftechnologie für Ingenieure
Verlag Pearson Studium, 2005

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

Coordinators: F. Gauterin
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.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 Ride Comfort & Acoustics II (eng.) [2114857]

Coordinators: F. Gauterin
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.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: Fluid Technology [2114093]

Coordinators: M. Geimer, M. Scherer, L. Brinkschulte
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Automotive Engineering I (eng.) [2113809]

Coordinators: F. Gauterin, M. Gießler
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.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: Basics of Manufacturing Technology [2149658]

Coordinators: V. Schulze, F. Zanger
Part of the modules: Manufacturing Processes (p. 20)[BSc-Modul 12, FertProz]

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 (1 hour).

Conditions
None

Recommendations
None

Learning Outcomes
The students ...

- are able to classify the manufacturing processes by their general functionality according to the specific main groups (DIN 8580).
- have the ability to declare and explain the function of the significant manufacturing processes of the main groups (DIN 8580).
- are enabled to describe the characteristic process features (geometry, materials, accuracy, tools, machines) of the significant manufacturing processes of the main groups (DIN 8580).
- have the ability to derive the relevant process specific technical advantages and disadvantages of the characteristic process features.
- are enabled to perform a selection of suitable manufacturing processes for given components.
- are enabled to classify the required manufacturing processes in the expiry of a process chain for the production of given sample products.

Content
The objective of the lecture is to classify the manufacturing technology within the wider context of production engineering, to provide an overview of the different manufacturing processes and to establish basic process knowledge of the common processes. The lecture conveys the basic principles of manufacturing technology and deals with the manufacturing processes based on example components 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 following topics will be covered:

- Primary processing (casting, plastics engineering, sintering, additive manufacturing processes)
- Forming (sheet-metal forming, massive forming)
- Cutting (machining with geometrically defined and geometrically undefined cutting edges, separating, abrading)
- Joining
- Coating
- Heat treatment and surface treatment

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

Literature
Lecture notes

Course: Global Logistics [3118095]

Coordinators: K. Furmans, T. Kivelä, K. Dörr
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.Sc.)]

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

Learning Control / Examinations
oral examination, 20 minutes

Conditions
Attendance during lectures is required

Recommendations
none

Learning Outcomes
Students are able to:

- describe material flow processes qualitativ and quantitativ,
- plan material flow systems, illustrate them in simple models and analyse them regarding their performance,
- use methods to determine performance indicators like throughput, utilization, etc.,
- describe logistical tasks,
- design logistical systems suitable to the respective task,
- determine essential influencing parameters on the bullwhip effect and
- use optimizing solution methods.

Content
Conveyor Systems

- Basic elements of conveyor systems
- Key figures
- Branching elements
  - continuous/partially-continuous
  - deterministic/stochastic switch
- Integration elements
  - continuous/partially-continuous
  - dispatching rules

Queueing Theory and Production Logistics

- Basic queueing systems
- Distributions
- M|M|1 and M|G|1 model

Application on production logistics, Distribution Centers and Order Picking

- The location problem
- Distribution centers

- Inventory management
- Order picking

Vehicle Routing and Types of vehicle routing problems

- Linear programming model and graph theoretic model
- Heuristics
- Supporting technologies

Optimization of Logistical Networks

- Objectives
- Cooperative strategies
- Supply chain management
- Implementation

Media
presentations, blackboard, book

Literature
Literature: Arnold, Dieter; Furmans, Kai : Materialfluss in Logistiksystemen; Springer-Verlag Berlin Heidelberg, 2009

Remarks
The course takes place in form of a block event, i.e. all lectures will be given in one week. The dates of the lecture, i.e. the respective week, will be published on the IFL homepage.

Course: Measurement and Control Systems [2137301]

Coordinators: C. Stiller
Part of the modules: Measurement and Control Systems (p. 36)[BSc-Modul 08, MRT]

ECTS Credits	Hours per week	Term	Instruction language
7	3	Winter term	de

Learning Control / Examinations
written exam; paper reference materials only (no calculator)

Conditions
Fundamentals in physics and electrical engineering; ordinary linear differential equations; Laplace transform

Learning Outcomes
Measurement and control of physical entities is a vital requirement in most technical applications. Such entities may comprise e.g. pressure, temperature, flow, rotational speed, power, voltage and electrical current, etc.. From a general perspective, the objective of measurement is to obtain information about the state of a system while control aims to influence the state of a system in a desired manner. This lecture provides an introduction to this field and general systems theory. The control part of the lecture presents classical linear control theory. The measurement part discusses electrical measurement of non-electrical entities.

Content
1 Dynamic systems
2 Properties of important systems and modeling
3 Transfer characteristics and stability
4 Controller design
5 Fundamentals of measurement
6 Estimation
7 Sensors
8 Introduction to digital measurement

Literature

- A Script is available as free pdf download
- Measurement and Control Systems:

R.H. Cannon: Dynamics of Physical Systems, McGraw-Hill Book Comp., New York,1967
G.F. Franklin: Feedback Control of Dynamic Systems, Addison-Wesley Publishing Company, USA, 1988
R. Dorf and R. Bishop: Modern Control Systems, Addison-Wesley
C. Phillips and R. Harbor: Feedback Control Systems, Prentice-Hall

- Regelungstechnische Bücher:

J. Lunze: Regelungstechnik 1 & 2, Springer-Verlag
R. Unbehauen: Regelungstechnik 1 & 2, Vieweg-Verlag
O. Föllinger: Regelungstechnik, Hüthig-Verlag
W. Leonhard: Einführung in die Regelungstechnik, Teubner-Verlag
Schmidt, G.: Grundlagen der Regelungstechnik, Springer-Verlag, 2. Aufl., 1989

- Messtechnische Bücher:

E. Schrüfer: Elektrische Meßtechnik, Hanser-Verlag, München, 5. Aufl., 1992
U. Kiencke, H. Kronmüller, R. Eger: Meßtechnik, Springer-Verlag, 5. Aufl., 2001
H.-R. Tränkler: Taschenbuch der Messtechnik, Verlag Oldenbourg München, 1996
W. Pfeiffer: Elektrische Messtechnik, VDE Verlag Berlin 1999
Kronmüller, H.: Prinzipien der Prozeßmeßtechnik 2, Schnäcker-Verlag, Karlsruhe, 1. Aufl., 1980

Course: Basics of Technical Logistics [2117095]

Coordinators: M. Mittwollen, J. Oellerich
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Advanced Mathematics I [0131000]

Coordinators: A. Kirsch, T. Arens, F. Hettlich
Part of the modules: Advanced Mathematics (p. 18)[BSc-Modul 01, HM]

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

Learning Control / Examinations
written examination (2h)

Conditions
Homework is mandatory and a precondition to take part at the exam “AM I”.

Learning Outcomes
The students know the basic facts and tools of one dimensional analysis.

Content
Basic concepts, sequences and convergence, functions and continuity, series, differntial calculus of one variable, integral calculus

Literature
Burg, Haf, Wille: Höhere Mathematik für Ingenieure,
Merziger, Wirth: Repetitorium der höheren Mathematik,
Arens, Hettlich et al: Mathematik

Course: Advanced Mathematics II [0180800]

Coordinators: A. Kirsch, T. Arens, F. Hettlich
Part of the modules: Advanced Mathematics (p. 18)[BSc-Modul 01, HM]

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

Learning Control / Examinations
precondition for the admission to the examination: certificate of homeworks (non graded)
written examination (graded)

Conditions
Homework is mandatory and a precondition to take part at the exam "AM 2".

Recommendations
courses of the 1st semester

Learning Outcomes
The students know the basics on vector spaces and multi-dimensional calculus and the basic techniques to solve differential equations.

Content
vector spaces, differential equations, Laplace transform, vector-valued functions of several variables

Literature
Burg, Haf, Wille: Höhere Mathematik für Ingenieure,
Merziger, Wirth: Repetitorium der höheren Mathematik,
Arens, Hettlich et al: Mathematik

Course: Advanced Mathematics III [0131400]

Coordinators: A. Kirsch, T. Arens, F. Hettlich
Part of the modules: Advanced Mathematics (p. 18)[BSc-Modul 01, HM]

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

Learning Control / Examinations
precondition for the admission to the examination: certificate for homeworks (non graded)
written examination (graded)

Conditions
Homework is mandatory and a precondition to take part at the exam “AM 3”.

Recommendations
courses of 1st and 2nd semester

Learning Outcomes
The students know techniques and applications of the multi-dimensional calculus (vector calculus) and have basic knowledge on partial differential equations and stochastics.

Content
Applications of multi-dimensional calculus, domain integral, vector analysis, partial differential equations, Fourier theory, stochastics

Literature
Burg, Haf, Wille: Höhere Mathematik für Ingenieure,
Merziger, Wirth: Repetitorium der höheren Mathematik,
Arens, Hettlich et al: Mathematik

Course: Computer Science for Engineers [2121390]

Coordinators: J. Ovtcharova
Part of the modules: Computer Science (p. 30)[BSc-Modul 09, Inf]

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

Learning Control / Examinations
Written examination

Duration: 3 hours (compulsory subject)

Auxiliary means: none

Conditions
Examination prerequisite: passed Lab Course [2121392]

Recommendations
None.

Learning Outcomes
The students can identify, explain and assign the repective context to the fundamental terms of information technology, such as data, signals, information, numeral systems, propositional logic, computer architectures, data structures, algorithms, database managements systems as well as the related concepts and theories.
In addition, they can efficiently implement the underlying theorys and concepts in form of procedural and object-oriented (Java) programs as well as analyze the source code and its corresponding function.

Content
Basics: Information representation- and processing, terms and definitions: alphabet, data, signals, information, numeral systems, propositional logic and Boolean algebra, computer architectures, programming paradigms.
Object Orientation: Definition and important characteristics of object orientation, Object-oriented modeling with UML.
Data Structures: Definition, properties and application of graphs, trees, linked lists, queues and stacks.
Algorithms: Characteristics of algorithms, complexity analysis, design methods, important examples.
Database management systems: Relational data model, relational algebra, declarative language SQL

Literature
Lecture notes
Robert Sedgewick: Algorithms in Java, Part 1-4, 3. Auflage, Addison Wesley, 2002, ISBN 0201361205.
Robert Sedgewick: Algorithms in Java, Part 5, 3. Auflage. Addison Wesley, 2003, ISBN 0201361213.
Gerhard Goos: Informatik 1. Eine einführende Übersicht, 4. Auflage, Springer Lehrbuch, 1992, ISBN 3540527907
Gerhard Goos: Informatik 2. Eine einführende Übersicht, 4. Auflage, Springer Lehrbuch, 1992, ISBN 3540555676
Sebastian Abeck: Kursbuch Informatik (Broschiert), Universitätsverlag Karlsruhe, 2005, ISBN-10: 3937300686
Russ Miles, Kim Hamilton: Learning UML 2.0, 1. Auflage, O'Reilly, 2006, ISBN 0596009828
Craig Larman: Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and Iterative Development, 3. Auflage. Prentice Hall, 2004, ISBN 0131489062
Peter Drake: Data Structures and Algorithms in Java. 1. Auflage. Prentice Hall, 2005, ISBN 0131469142
Thomas Rießinger: Informatik für Ingenieure und Naturwissenschaftler: Eine anschauliche Einführung in das Programmieren mit C und Java, Springer, 2005, ISBN-10: 3540262431
Raghu Ramakrishnan, Johannes Gehrke: Database Management Systems, 3. Auflage, McGraw-Hill, 2003, ISBN 0072465638

Course: Machine Vision [2137308]

Coordinators: C. Stiller, M. Lauer
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.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: Machines and Processes [2185000]

Coordinators: H. Kubach, M. Gabi, H. Bauer, U. Maas
Part of the modules: Machines and Processes (p. 34)[BSc-Modul 11, MuP]

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

Learning Control / Examinations
successful lab course and written exam (3h)
Participation in the exam is only possible after completing the lab course successfully

Conditions
Successful lab course is a precondition for participation in the exam.

Learning Outcomes
The students can name and describe basic energy conversion processes and energy converting machines. They can explain the application of these energy conversion processes in various machines. They can analyze and evaluate the processes and machines in terms of functionality and efficiency and they are able to solve basic technical problems in terms of operating the machines.

Content
basics of thermodynamics and combustion
thermal fluid machines

- steam turbunes
- gas turbines
- combined-cycle plants
- turbines and compressors
- aircraft engines

hydraulic fluid machines

- oerating performance
- characterization
- control
- cavitation
- wind turbines, propellers

internal combustion engines

- characteristic parameters
- engine parts
- kinematics
- engine processes
- emissions

Media
slides to download
Documentation of the labcourse

Remarks
Lab course and lecture take place in summer and winter semester.
In the SS the lecture is held in English. The lab course is always bilingual.

Course: Machine Dynamics [2161224]

Coordinators: C. Proppe
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.Sc.)], Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Mechanical Design I [2145178]

Coordinators: A. Albers, S. Matthiesen
Part of the modules: Mechanical Design (p. 22)[BSc-Modul 10, MKL (2016)]

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

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&C²-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&C²-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
- Contact&Channel-Approach (C&C²-A)

Basics of selected technical components

- springs
- bearings

Concomitant to the lectures, tutorials take place with the following contents:
Gear workshop
Tutorial “tools of visualization (technical drawing)”
Tutorial “technical systems product development, sytem theory, element model C&CM”
Tutorial “springs”
Tutorial “bearing and bearing arrangements”

Media
Beamer
Visualizer
Mechanical components

Literature
Lecture notes:
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:
The Productdevelopment knowledge base PKB will be provided in digital form for registered students. All lecture notes and additional slides will be provided in Ilias.

Course: Mechanical Design I [2145186]

Coordinators: A. Albers, N. Burkardt
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.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&C²-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&C²-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: Mechanical Design II [2146178]

Coordinators: A. Albers, S. Matthiesen
Part of the modules: Mechanical Design (p. 22)[BSc-Modul 10, MKL (2016)]

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

Learning Control / Examinations
Concomitant to the lecture, 2 online tests are carried out and the knowledge from the lecture will be tested. The knowledge from mechanical design I and II will further be controlled with a design and a CAD task.
Further information will be announced on ILIAS and at the beginning of the lecture mechanical design II.

Conditions
Successful participation in mechanical design I.

Learning Outcomes
The students are able to ...

- evaluate different bearing arrangements according to their particular application and characteristics and describe system specific phenomena.
- dimension bearing arrangements and choose, evaluate and dimension suitable bearings.
- name and describe the function principals of different sealings as well as evaluate and use special sealings under consideration of particular boundary conditions and choosing criteria.
- use the basic rules of designing on concrete problems. They understand the different designing stages and are able to name and take into account the requirements of designing.
- describe manufacturing processes and their caracteristics, as well as derive and use the resulting boundary conditions of designing.
- choose and dimension bolt connections for different boundary conditions.

Content
Bearings
Sealings
Design
Bolt Connections
Tutorials take place concomitant to the lectures.

Media
Beamer
Visualizer
Mechanical components

Literature
Konstruktionselemente des Maschinenbaus - 1 und 2
Grundlagen der Berechnung und Gestaltung von
Maschinenelementen;
Steinhilper, Sauer, Springer Verlag, ISBN 3-540-22033-X ,
also available as electronic paper at the KIT catalogue.
Grundlagen von Maschinenelementen für Antriebsaufgaben;
Steinhilper, Sauer, Springer Verlag, ISBN 3-540-29629-8

Remarks
Lecture notes:
All lecture notes and additional slides will be provided in ILIAS.

Course: Mechanical Design III [2145151]

Coordinators: A. Albers, S. Matthiesen
Part of the modules: Mechanical Design (p. 22)[BSc-Modul 10, MKL (2016)]

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

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.
Further information will be announced in Ilias and at the beginning of the lecture mechanical design III.

Conditions
None

Learning Outcomes
The students are able to ...

- recognize the importance of the microstructure of die surfaces in technical surfaces for their function. You know a system for the description of the die face fine structure in technology and characteristic values for the description of the surface fine structure of die faces both in their definition and in their statement and in the quantitative order of magnitude.
- know and can explain surface measuring principles.
- know the connection of the surface structure with the manufacturing processes and the costs.
- know the purpose of standards, types of standards and standard numbers.
- detect tolerances as a description of the geometry of die surfaces and can define them. You know the structure, type and structure of the ISO fitting system and can use it.
- can explain the different types of tolerance and their significance for the economic product development process.
- can represent and explain basic functions of shaft-hub connections in general.
- know a selection of different component connections to the respective operating principles and can explain these.
- can explain the function of the component connection "centering" and display it in a technical drawing.
- understand in principle positive and non-positive shaft-hub-connections and can explain them. You can
- dimension a cylindrical compression joint (calculation and dimensioning criteria) and understand the stresses at a cylindrical compression joint and can display them graphically.
- understand the function of gears in the context of drive system technology.
- know different operating principles of gears and different designs of gear drives.
- know and understand the law of gearing. They know designations on the gear wheel and various flank curves.
- understand gear mesh and the application limits and damage to gears. You know the basic ideas of gear dimensioning.
- know and understand recirculating gear units as a design. They understand the operating principle of hydraulic transmissions.

Content
component connection
Tolerances and fittings
gears

Media
Beamer
Visualizer
Mechanical components

Literature
Lecture notes:
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
CAD:
3D-Konstruktion mit Pro/Engineer - Wildfire, Paul Wyndorps, Europa Lehrmittel, ISBN: 978-3-8085-8948-9
Pro/Engineer Tipps und Techniken, Wolfgang Berg, Hanser Verlag, ISBN: 3-446-22711-3(für Fortgeschrittene)

Remarks
Lecture notes:
The Productdevelopment knowledge base PKB will be provided in digital form for registered students. All lecture notes and additional slides will be provided in Ilias.

Course: Mechanical Design IV [2146177]

Coordinators: A. Albers, S. Matthiesen
Part of the modules: Mechanical Design (p. 22)[BSc-Modul 10, MKL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
8	3	Summer term	de

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.
Further information will be announced in Ilias and at the beginning of the lecture mechanical design IV.

Conditions
Successful participation in mechanical design I, mechanical design II and mechanical design III.

Learning Outcomes
The students are able to ...

- name the reasons for using shaft-clutches (in short: “Clutches”)
- name exemplary applications of clutches
- list basic functions of clutches and delimit clutches to transmissions
- indicate the basic power balance of a clutch
- mention various ancillary functions that occur with clutches
- name various criteria for classifying clutches
- describe the shape-function relationship for a given clutch for both main and secondary functions
- derive the main and auxiliary functions required for a given application, select a suitable clutch (and, if necessary, also a specific size) or, if necessary, combine several clutches
- explain interactions of clutches with adjacent subsystems, possibly specific to certain designs or groups of clutches
- design clutches to fulfil the required main and auxiliary functions
- integrating clutches into technical systems
- specify selection criteria for clutches
- explain central design principles for different groups of clutches, including the designation of key design targets
- for frictionally engageable clutches, slip time, transferable torque and thermal resistance should be designed roughly under the assumptions and simplifications dealt with in the lecture, estimate the relevant loads by the surrounding technical system and, if necessary, influence the specified target values by design measures
- apply relevant standards for the design of clutches
- name possible failure modes for given clutches
- specify which design measures on a clutch can be used to influence the dynamic behaviour of the surrounding system in a desired direction
- explain the various possible actuation types for switchable clutches and give examples of corresponding clutch designs
- explain the target values of the economic dimensioning

- explain what are the main results of a dimensioning process
- explain the scope of the dimensioning (economic and legal significance)
- explain the basic sizing procedure and record it as a generic flowchart
- explain uncertainties in dimensioning
- specify the different basic procedures, both for dimensioning and for determining the influencing variables, e.g. loads, as well as their advantages or disadvantages in relation to each other
- explain different types of calculation methods and their characteristics (static/dynamic, local vs. nominal voltages)
- name different types of failure (implies the definition of failure)
- explain possible causes of failure
- provide suitable replacement models for simple subsystems of technical systems as a basis for dimensioning
- explain different basic load types for given examples Dominant load types relevant to design
- use the basics of elasto-statics for all basic load cases to design components that can be modeled as linear structures according to the nominal stress concept
- describe the dimensioning parameters presented in the VL and their use (shape number, shape yield strength, shape yield strength ratio)
- explain the purpose of strength hypotheses
- explain the strength hypotheses for metallic materials presented in the VL and select them according to the specific situation
- explain the principal effects of notches, including the factors affecting the magnitude of these effects
- describe how notches can be taken into account in the dimensioning process
- notched components that can be modelled as linear load-bearing structures for static loads
- explain possibilities for determining the strength of a material or component
- name influencing variables on the loadability and derive measures from them in order to influence the loadability of a component if necessary
- describe different types of material behaviour under overelastic stressing of metallic materials
- describe dynamic loads
- from Wöhler, Haigh- or Smith-diagrams determine material characteristics for the loadability under given load conditions
- construct the Smith-diagramm approximately with the given characteristic values
- explain the difference between strength and fatigue strength
- Components that can be modeled as linear load-bearing structures according to the nominal stress concept for dynamic loads in base load cases and combined loads in the same phase
- for components that can be modeled as linear structures, explain the design approach presented in the lecture for any combined, dynamic loads
- perform strength analyses in accordance with DIN 743, in the course of which even failure-critical points in the component can be identified and, if the result is negative, appropriate measures can be derived and evaluated
- name factors influencing the safety factors to be selected and explain what type of influence this is
- differentiate between different areas of fluid technology on the basis of essential aspects of the operating principles

- identify properties/ special features of fluid technology systems and the resulting areas of application
- explain basic approaches for the design of hydraulic systems
- differentiate the flow types shown in the lecture
- with the basic equations (continuity equation, Bernoulli,...) of hydrostatics and hydrodynamics explained in the lecture
- Identify sources of pressure losses in hydraulic systems and influencing factors
- designate basic subsystems of a hydraulic system
- assign system and component examples shown in the lecture to components of a hydraulic system
- name the symbols shown in the lecture and assign them to the respective system/component
- use symbols to explain the function of simple hydraulic systems
- draw up function diagrams for hydraulic systems that are similar in complexity to the systems shown in the lecture

Content
Dimensioning
Clutches
Hydraulics

Media
Beamer
Visualizer
Mechanical components

Literature
Lecture notes:
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

Course: Materials and Devices in Electrical Engineering [23211]

Coordinators: A. Weber
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.Sc.)]

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

Learning Control / Examinations
Written Exam

Conditions
None.

Learning Outcomes
The lecture provides fundamental knowledge about Materials and Devices applied in Electrical Engineering.
The lecture of “Materials and Devices in Electrical Engineering” concerns the fundamental ideas of the electrical materials. It contains the minimum subject matter which can be recommended to the studying of “Electrical Engineering”.

Content
Materials play a central role for the progress of technology and economy. Their applications determine the innovation degree of modern technologies like the information-, energy-, traffic-, manufacturing-, environmental and medical technology. Many innovations in electrical engineering could only be realized on the basis of new material and production engineering. Therefore the development of materials and their applications in systems become one of the key fields of the industrial technology in the 21st century with outstandingly high strategic meaning.
The lecture of “Materials and Devices in Electrical Engineering” concerns the fundamental ideas of the electrical materials.
Topics covered: Structure of Atoms and Solids, Electrical Conductors, Dielectric Materials, Magnetic Materials

Literature
William D. Callister, Materials Science and Engineering, John Wiley & Sons, Inc.,ISBN No. 0-471-32013-7

Remarks
Copies of the slides are available at http://www.iwe.kit.edu/.

Course: Mathématiques appliquées aux sciences de l'ingénieur [2161230]

Coordinators: J. Dantan
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

ECTS Credits	Hours per week	Term	Instruction language
5	2	Winter / Summer Term	fr

Learning Control / Examinations
oral / written

Conditions
None.

Recommendations
HM I-III

Learning Outcomes
The students have a good command of the basics of probability theory and Laplace transformation. The lecture then introduces into the application of the basics in the following fields of mechanics: functional safety of structural components, reliability of components and systems, vibrations and control systems.

Content
Courses are taught in French.
First block course at the KIT:
Basics of probability theory and Laplace transformation
Second block course at the Arts et Métiers ParisTech, centre Metz, France
Application of mathematics in the fields of functional safety of structural components, reliability of components and systems, vibrations and control systems.
A visit to an industry partner in the vicinity of Metz will be planned.

Remarks
The second block course will probably take place 1-2 days in Metz. KIT-DeFI will be responsible for the organisation and bear the expenses for the students interested.
Further information: www.itm.kit.edu/dynamik und www.defi.kit.edu.

Course: Mathematical Methods in Dynamics [2161206]

Coordinators: C. Proppe
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Modelling of Microstructures [2183702]

Coordinators: A. August, B. Nestler, D. Weygand
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Numerical methods and simulation techniques [2183703]

Coordinators: B. Nestler
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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 Physics for Engineers [4040311]

Coordinators: B. Pilawa
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Physics for Engineers [2142890]

Coordinators: P. Gumbsch, A. Nesterov-Müller, D. Weygand, T. Förtsch
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Product Lifecycle Management [2121350]

Coordinators: J. Ovtcharova, T. Maier
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Radar Systems Engineering [23405]

Coordinators: W. Wiesbeck
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.Sc.)]

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

Learning Control / Examinations
Written Exam

Conditions
None.

Learning Outcomes
The goal is to understand the Radar principles and gain knowledge about modern Radar systems.
Based on Electromagnetic field theory, the lecture provides fundamentals of radar principles, system parameters and advanced techniques related to the system hardware and processing. From this lecture students are expected to learn how system engineering practically contributes to a radar system implementation.

Content
Subjects dealt in this lecture are closely related to the ongoing research works in the institute. The lecture starts with a short historical review of the development in radar systems. The further contents of this lecture are categorized into three major parts.
The first part of this lecture focuses on the fundamental disciplines required for understanding radar principles. The propagation phenomena of electromagnetic waves, such as reflection, diffraction, and scattering fundamentals, are important subject to understand the radar signal propagation and delivered target information. This subject is related to the derivation of the radar equation that is the most critical formula in radar system engineering. It is expected that the students develop the skill to derive the radar equation for various configurations and scenarios. The basic radar principles are introduced in this part as well as system parameters. A radar system performance is quantified by several system parameters like accuracy, false alarm rate, sensitivity, and noise parameter of the system. These system parameters are mathematically derived and the theoretical relation (trade-off) between parameters is addressed in this part.
The second part deals with radar system configurations and system features. The system configuration depends on the purposes and applications. This part introduces various radar system configurations from a pulse radar system to advanced radar concepts, such as Moving Target Indicator (MTI) and Synthetic Aperture Radar (SAR) and analyzes the system functionality. Furthermore, the details about system hardware and the subjects related to the system implementation are dealt, for example Radar Cross Section (RCS) measurement technique for system calibration. In addition, students are supposed to learn basic radar signal processing techniques that conduct the pulse compression. It is worth since the system performance can be evaluated by the quality of data efficiently recovered by the signal processing techniques.
The last part dedicates to introducing emerging techniques for future radar systems. A promising system concept with Digital Beam Forming (DBF) will be the main stream in this part. Compared to a conventional radar system based on the phased array antenna, the advantages and disadvantages are addressed at diverse angles. This advanced system concept is applicable to automotive radar systems and High Resolution Wide Swath (HRWS) SAR system. The lecture provides not only the technical description for the DBF radar system concept, but also challenges waiting for solutions, so that students could be encouraged to involve their master thesis on those topics.

Literature
Werner Wiesbeck, Lecture script „Radar Systems Engineering.“

Remarks
Current information can be found on the IHE (http://www.ihe.kit.edu) webpage.

Course: Space-born Microwave Radiometry - Advanced Methods and Applications [23448]

Coordinators: H. Süß
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.Sc.)]

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

Learning Control / Examinations
Oral exam

Conditions
None.

Learning Outcomes
Fundamentals of passive microwave sensing, applications of microwave radiometry on ground based, air and space borne platforms; presentation of modern methods in security applications.

Content
The focal points of the lecture are:
Propagation of electromagnetic waves
Radiation properties of matter and radiation laws
Description of radiometers
Measurements and technologies
Imaging line scanners
Aperture synthesis radiometer
Fully polarimetric radiometers
Application examples for imaging of the earth surface, oil spill detection, imaging of infrastructures
Detection of hidden objects e.g. anti-personal-mines, weapons and explosives

Literature
B. Vowinkel „Passive Mikrowellenradiometrie“ Vieweg-Verlag
F.T. Ulaby, et al „Microwave Remote Sensing“ Vol 1

Remarks
Actual information can be found at the internet page of the IHE (www.ihe.kit.edu).

Course: Fluid Mechanics I [2154512]

Coordinators: B. Frohnapfel
Part of the modules: Mechanics of Fluids (p. 27)[BSc-Modul 05, SL (2016)]

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

Learning Control / Examinations
combined with 2153512 Strömungslehre II
written
180 min

Conditions
None.

Recommendations
Successfully completed Advanced Mathematics I-III
basic knowledge about physics and ordinary linear differential equations

Learning Outcomes
The students can name characteristic properties of fluids and distinguish them from solids. They are able to discuss and compute pressure distributions in static fluids and the resulting forces. They know how to describe kinematic flow properties and can compute incompressible and compressible flows without losses (i.e. apply streamtube theory). They can estimate losses in turbulent pipes. The students know the relevance of dimensionless numbers and can distinguish characteristic flow states based on those.

Content
Properties of Fluids, Surface Tension, Hydro- and Aerostatics, Kinematics, Stream Tube Theory (compressible and incompressible), Losses in Pipeline Systems, Dimensional Analysis, Dimensionless Numbers

Literature
Kundu, P.K., Cohen, K.M.: Fluid Mechanics, Elsevier, 4th Edition, 2008
Durst, F.: Fluid Mechanics: An Introduction to the Theory of Fluid Flows, Springer 2008
Batchelor, G.K.: An Introduction to Fluid Dynamics, Cambridge Mathematical Library

Course: Fluid Mechanics II [2153512]

Coordinators: B. Frohnapfel
Part of the modules: Mechanics of Fluids (p. 27)[BSc-Modul 05, SL (2016)]

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

Learning Control / Examinations
combined with 2154512 Strömungslehre I
written
180 min

Conditions
None.

Recommendations
Successfully completed Advanced Mathematics I-III
basic knowledge about physics and ordinary linear differential equations
Knowledge of Mechanics of Fluids I

Learning Outcomes
The students know how to derive the fundamental equations for mass and momentum conservation and can introduce material laws for fluids into those. They can discuss the physical meaning of the different terms in the Navier-Stokes-Equations. They are capable of simplifying the mathematical equations that describe the motion of fluids and can compute flow quantities for generic problems based on these simplified equations. This includes the calculation of static and dynamic forces acting from the fluid onto the solid as well as the detailed analysis of two-dimensional viscous flows.

Content
Introduction to Tensor Notation, Fluid Elements in a Continuum, Conservation of Mass and Momentum, Reynolds Transport Theorem, Integral Form of Mass and Momentum Conservation, Forces between Fluids and Solids, Material Laws of Fluids, Analytic Solutions of the Navier-Stokes Equations

Literature
Kundu, P.K., Cohen, K.M.: Fluid Mechanics, Elsevier, 4th Edition, 2008
Schlichting, H.: Boundary Layer Theory, McGraw-Hill
Batchelor, G.K.: An Introduction to Fluid Dynamics, Cambridge Mathematical Library

Course: Systematic Materials Selection [2174576]

Coordinators: S. Dietrich
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Fundamentals of Combustion Engine Technology [2133123]

Coordinators: S. Bernhardt, H. Kubach, J. Pfeil, O. Toedter, U. Wagner, A. Velji
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Integrated Information Systems for engineers [2121001]

Coordinators: J. Ovtcharova
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Engineering Mechanics I [2161245]

Coordinators: T. Böhlke, T. Langhoff
Part of the modules: Engineering Mechanics (p. 19)[BSc-Modul 02, TM]

ECTS Credits	Hours per week	Term	Instruction language
7	5	Winter term	de

Learning Control / Examinations
written, 90 min. Permitted resources in the exam will be announced.
Prerequisites by solving homework problems and attestations during the associated lab course.

Conditions
Mandatory participation in the assciated lab course.

Recommendations
None.

Learning Outcomes
The students can

- analyse different equilibrium systems based on the notion of forces and moments, e.g. plane and spatial force systems on a rigid body
- compute internal forces and moments for linear structures and as a result analyse and evaluate the internal load
- compute systems under the influence of friction
- determine the center of lines, areas, masses and volumes
- apply the principal of virtual displacements
- evaluate the stability of equilibrium positions
- compute and evaluate the load of straight bars in the framework of thermoelasticity
- list elastic-plastic material laws
- solve worksheet problems about topics of the lecture using the computer algebra system MAPLE

Content

- basics of vector calculus
- force systems
- statics of rigid bodies
- internal forces and moments in bars and beams
- friction
- centre of gravity, centre of mass
- work, energy, principle of virtual work
- statics of inextensible ropes
- elastostatics of tension-compression-bars

Literature
lecture notes
Hibbeler, R.C: Technische Mechanik 1 - Statik. Prentice Hall. Pearson Studium 2005.
Gross, D. et al.: Technische Mechanik 1 - Statik. Springer 2006.
Gummert, P.; Reckling, K.-A.: Mechanik. Vieweg 1994.
Parkus, H.: Mechanik der festen Körper. Springer 1988.

Course: Engineering Mechanics II [2162250]

Coordinators: T. Böhlke, T. Langhoff
Part of the modules: Engineering Mechanics (p. 19)[BSc-Modul 02, TM]

ECTS Credits	Hours per week	Term	Instruction language
6	5	Summer term	de

Learning Control / Examinations
written, 90 min. Additives as announced
Prerequisites by solving homework problems and attestations during the associated lab course.

Conditions
Mandatory participation in the assciated lab course.

Recommendations
None.

Learning Outcomes
The students can

- compute stresses and strains in beams in case of straight and unsymmetric bending
- compute stresses and strains in bodies under torsional load
- compute stresses and strains in beams in case of shear force loading
- compute and evaluate 3D stress and strain states
- apply energy methods for computing
- compute approximate solutions using the methods of Ritz and Galerkin
- analyse the stability of straight bars under compressive loads and evaluate on the basis of the buckling forces
- can solve worksheet problems to topics of the lecture using the computer algebra system MAPLE

Content

- bending
- shear
- torsion
- stress and strain state in 3D
- Hooke's law in 3D
- elasticity theors in 3D
- energy methods in elastostatics
- approximation methods
- stability
- inelastic material behaviour

Literature
lecture notes
Hibbeler, R.C: Technische Mechanik 2 - Festigkeitslehre. Prentice Hall. Pearson Studium 2005.
Gross, D. et al.: Technische Mechanik 2 - Elastostatik. Springer 2006.
Gummert, P.; Reckling, K.-A.: Mechanik. Vieweg 1994.
Parkus, H.: Mechanik der festen Körper. Springer 1988.

Course: Engineering Mechanics III [2161203]

Coordinators: W. Seemann, Assistenten
Part of the modules: Engineering Mechanics (p. 19)[BSc-Modul 02, TM]

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

Learning Control / Examinations
written exam

Duration: 3h (including EM III and EM IV) for Mechanical Engineering and for Techno-mathematics
1,5 h (only EM III) for mechatronics und information technicians
Resources allowed during exam: own lecture notes and notes from tutorial, books in 'Engineering Mechanics'

Conditions
Homework is mandatory and a precondition for participation in the exam "Engineering Mechanics III/IV" (Mechanical Engineering, techno-mathematics) and for participation in the exam "Engineering Mechanics III" (Mechatronics and information technicians)

Recommendations
None.

Learning Outcomes
The students are able to derive models of systems for a plain motion. This includes both kinematics as well as dynamics. They know how to describe the motion of particles in reference systems and may derive kinematic quantities like velocity or acceleration. The derivation of equations of motion for systems of particles and rigid bodies with Newton-Euler's axioms can be done. The students know the dependence of the kinetic energy on the kinematic quantities and the inertia parameters of the system and can apply the principle of work or the principle of the conservation of mechanical energy for conservative systems. Applications include impact problems as well as systems with increasing or decreasing mass.

Content
Kinematics: Cartesian, cylindrical and natural coordinates. Time derivatives in moving reference frames, angular velocities of reference frames.

Kinetics of a particle:
Newton's axiom, Principle of d'Alembert, work of a force, kinetic and potential energies, principle of linear momentum, principle of moment of momentum, kinetics in moving reference systems

Systems of particles:
Principle of center of mass, Principle of moment of momentum, impacts between particles, systems with variable mass, applications.

Plain motion of rigid bodies:
Pure translation, pure rotation, general plain motion. Instantaneous center of rotation, Kinetics, moment of momentum, principle of work and principle of energy conservation for a rotation around a space-fixed axis. Mass moment of inertia, parallel-axis-theorem.Principle of linear momentum and principle of moment of momentum for arbitrary plain motion. Principle of d'Alembert for plain motion. Principles of linear and moment of momentum in integral form. Applications for impact problems.

Literature
Hibbeler: Technische Mechanik 3, Dynamik, München, 2006

Gross, Hauger, Schnell: Technische Mechanik Bd. 3, Heidelberg, 1983

Lehmann: Elemente der Mechanik III, Kinetik, Braunschweig, 1975

Göldner, Holzweissig: Leitfaden der Technischen Mechanik.

Hagedorn: Technische Mechanik III.

Course: Engineering Mechanics IV [2162231]

Coordinators: W. Seemann, Assistenten
Part of the modules: Engineering Mechanics (p. 19)[BSc-Modul 02, TM]

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

Learning Control / Examinations
written exam: 3h (together with TM III)

Conditions
Homework is mandatory and a precondition to take part in the exam “Engineering Mechanics III/IV”.

Learning Outcomes
The students know some possibilities to describe the position and orientation of a rigid body for an arbitrary 3D motion. They realize that the rotational velocity is a vector which may change both magnitude and orientation. They can apply the principle of linear momentum and the principle of moment of momentum to a spatial motion of a rigid body and notice that this is much more complicated compared to a plain motion. The students can calculate the coordinates of the inertia tensor. They see that many effects which may be seen with gyroscopes can be explained by the principle of moment of momentum. For systems with many particles or bodies but only few degrees of freedom the students know that the application of analytical methods like the principle of D'Alembert in Lagrangian form or the Lagrange equations may be advantageous. They can apply these principles to simple problems. For vibration problems the students can interprete the most important expressions like eigenfrequency, resonance or eigenvalue problem. Forced vibration of systems with one degree of freedom can be investigated by the students.

Content
Spatial kinematics of a rigid body, Euler angles, angular velocity using Euler angles, Euler's equations, inertia tensor, kinetic energy of a rigid body, free gyroscopes, forced gyroscopes, systems of rigid bodies, principle of d'Alembert, Lagrange's equations of the first and second kind, generalized coordinates, free and forced vibration of one degree of freedom systems, frequency response, vibration of multi degree of freedom systems, vibration absorption

Literature
Hibbeler: Technische Mechanik 3, Dynamik, München, 2006
Marguerre: Technische Mechanik III, Heidelberger Taschenbücher, 1968
Magnus: Kreisel, Theorie und Anwendung, Springer-Verlag, Berlin,
1971 Klotter: Technische Schwingungslehre, 1. Bd. Teil A, Heidelberg

Course: Vibration Theory [2161212]

Coordinators: A. Fidlin
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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 Thermodynamics and Heat Transfer I [2165501]

Coordinators: U. Maas
Part of the modules: Engineering Thermodynamics (p. 26)[BSc-Modul 04, TTD]

ECTS Credits	Hours per week	Term	Instruction language
8	5	Winter term	de

Learning Control / Examinations
Written exam: 2 hours

Conditions
Prerequisite: attestation each semester by homework assignments

Recommendations
Attendance of the exercise course (2165502 - Exercise course Technical Thermodynamics and Heat Transfer I)
Attendance of the tutorial (2165503 - Tutorial Technical Thermodynamics and Heat Transfer I)

Learning Outcomes
After completing the course students can:

- describe the correlations between the chemical and thermodynamic properties of pure substances.
- setup the balance equations for mass and energy for different processes.
- determine the direction of a process.
- understand the fundamental processes in phase transitions.
- explain the basics of ideal thermodynamic cycles.

Content
System, properties of state
Chemical and thermodynamic properties of pure components
Absolute temperature, model systems
1st law of thermodynamics for resting and moved systems
Entropy and 2nd law of thermodynamics
Behavior of real substances described by tables, diagrams and equations of state
Machine processes

Media
Blackboard and Powerpoint presentation

Literature
Course note packet
Elsner, N.; Dittmann, A.: Energielehre und Stoffverhalten (Grundlagen der technischen Thermodynamik Bd. 1 und 2), 8. Aufl., Akademie-Verlag, 680 S. 1993.
Baehr, H.D.: Thermodynamik: eine Einführung in die Grundlagen und ihre technischen Anwendungen, 9. Aufl., Springer-Verlag, 460 S., 1996.

Course: Technical Thermodynamics and Heat Transfer II [2166526]

Coordinators: U. Maas
Part of the modules: Engineering Thermodynamics (p. 26)[BSc-Modul 04, TTD]

ECTS Credits	Hours per week	Term	Instruction language
7	5	Summer term	de

Learning Control / Examinations
Written exam: 2 hours

Conditions
Prerequisite: attestation each semester by homework assignments

Recommendations
Attendance of the exercise course (2166555 - Exercise course Technical Thermodynamics and Heat Transfer II)
Attendance of the tutorial 2166556 - Tutorial Technical Thermodynamics and Heat Transfer II)

Learning Outcomes
After attending the course students are able to:

- describe the correlation between the thermodynamic properties in mixtures of different substances.
- explain the characteristics of real substances.
- define the major concepts in gas kinetics.
- determine the composition of a reacting mixture in the thermodynamic equilibrium.
- discuss the various influences on the reaction equilibrium.
- describe the fundamental laws of heat transfer.

Content
Repetition of the topics of “Thermodynamics and Heat Transfer I”
Mixtures of ideal gases
Moist air
Behaviour of real substances described by equations of state
Applications of the laws of thermodynamics to chemical reactions

Media
Blackboard and Powerpoint presentation

Literature
Course notes
Elsner, N.; Dittmann, A.: Energielehre und Stoffverhalten (Grundlagen der technischen Thermodynamik Bd. 1 und 2), 8. Aufl., Akademie-Verlag, 680 S. 1993.
Baehr, H.D.: Thermodynamik: eine Einführung in die Grundlagen und ihre technischen Anwendungen, 9. Aufl., Springer-Verlag, 460 S., 1996.

Course: Thermal Turbomachines I [2169453]

Coordinators: H. Bauer
Part of the modules: Lectures in English (B.Sc.) (p. 155)[Englischsprachige Veranstaltungen (B.Sc.)]

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: Heat and Mass Transfer [2165512]

Coordinators: U. Maas
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Wave and Quantum Physics [2400412]

Coordinators: B. Pilawa
Part of the modules: Physics (p. 28)[BSc-Modul 06, Ph (2016)]

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

Learning Control / Examinations
written exam, 2 h

Conditions
none

Learning Outcomes
The students

- are familiar with the properties of waves and can discuss those
- can reflect on the principles of relativity
- comprehend the coherence of the particle and wave description of light and matter
- can explain the limits of wave physics
- are able the apply the Schrödinger-equation to basic problems in quantum mechanics
- can explain the basic properties of atoms, especially for the hydrogen atom
- can discuss fundamental aspects of the electronic properties of solids

Content

- Properties of waves
- Acoustic and electromagnetic waves
- Interference and diffraction
- Relativity
- Wave-particle dualism
- Basic properties of atoms
- Basic electronic properties of solids

Literature
Paul A. Tippler: Physics for Scientits and Engineers

Course: Materials Science I [2173550]

Coordinators: H. Seifert, S. Ulrich, M. Heilmaier, A. Pundt
Part of the modules: Materials Science and Engineering (p. 23)[BSc-Modul 03, WK]

ECTS Credits	Hours per week	Term	Instruction language
7	5	Winter term	de

Learning Control / Examinations
Combined with 'Materials Science II'; oral; about 25 minutes
The successful partcipation in the lab course is obligatory for the admission to the examination.

Conditions
None.

Learning Outcomes
The students are able to describe the relationship between atomic structure, microscopical observations, and properties of solid materials.

The students can describe the typical property profies and can name applications for the most important engineering materials.

The students are able to describe standard materials characterization methods and can explain the evaluation of these methods. They can judge materials on base of the data obtained by these methods.

Content
Structure of atoms and atomic bonding
Crystalline solids
Defects in crystalline solids
Amorphous and partially crystalline solids
Constitution of alloys and materials
Diffusion and phase transformation in the solid state
Microscopic characterization method
Characterization with X-Rays and neutrons
Non-destructive Testing
Mechanical Testing

Literature
Lecture Notes; Problem Sheets;

Shackelford, J.F.
Werkstofftechnologie für Ingenieure
Verlag Pearson Studium, 2005

Course: Materials Science II for mach, IP-M, phys [2174560]

Coordinators: M. Heilmaier, H. Seifert, S. Ulrich, A. Pundt
Part of the modules: Materials Science and Engineering (p. 23)[BSc-Modul 03, WK]

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

Learning Control / Examinations
Combined with 'Materials Science I'; oral; about 25 minutes
The successful partcipation in the lab course is obligatory for the admission to the examination.

Conditions
Materials Science I

Learning Outcomes
The students can name representative materials for different material classes and can describe the differences.
The students are able to describe the basic mechanisms of hardening for ferrous and non-ferrous materials and reflect these mechanisms using phase and TTT diagrams.
The students can interpret given phase, TTT or other diagrams relevant for materials science, gather information from them and can correlate them regarding the microstructure evolution.
The students can describe the phenomena correlated with materials science in polymers, metals and ceramics and depict differences.
The students know about standard materials characterization methods and are able to asses materials on base of the data obtained by these methods.

Content
Iron based alloys
Non-iron based alloys
Ceramics
Glases
Polymers
Composite Materials

Literature
Lecture Notes; Problem Sheets;

Shackelford, J.F.
Werkstofftechnologie für Ingenieure
Verlag Pearson Studium, 2005

Course: Scientific computing for Engineers [2181738]

Coordinators: D. Weygand, P. Gumbsch
Part of the modules: Compulsory Elective Course (BSc) (p. 38)[BSc-Modul 15, WPM]

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: Workshop ’Working Methods in Mechanical Engineering’ (AIA) [2106984]

Coordinators: M. Lorch
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
Strengthening of students’ skills and abilities in
- scientific writing
- literature research and citation techniques
- time management
- teamwork
- presentation and communication skills

Content
- Scientific working techniques
- Literature research
- Project management
- Time management
- Scientific elaborations
- Presentation techniques
- Communication skills

Course: Workshop 'Working Methods in Mechanical Engineering' (FAST - Bahnsystemtechnik) [2114990]

Coordinators: P. Gratzfeld
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
The students should be able:
1. To plan a definite task under the consideration of specific regulations in a goal- and resource-oriented way.
2. To find and chose scientific information according to pre-defined quality criteria.
3. To write a precise and conclusive scientific abstract and to evaluate scientific papers.
4. To prepare a poster and an oral presentation in order to present scientific information.
5. To work in a team in a motivating and team-oriented way.

Content
Workshop 1: literature research, teamwork rules & roles , work organisation
Workshop 2: creativity techniques, decision making methods
Workshop 3: feedback rules, to get to know two types of scientific presentations - poster and oral presentation
Workshop 4: scientific presentations

Media
Handout online available for download

Course: Workshop 'Working Methods in Mechanical Engineering' (FAST - Fahrzeugtechnik) [2114989]

Coordinators: F. Gauterin, Gießler, Unrau
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

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

- plan their work under consideration of resources and available time,
- use creative methods in a team,
- find useful data sources, analyze and evaluate scientific papers to find input for their own works,
- shortly summarize their work results in a written document,
- visualize and present scientific information and their work results,
- work in a team.

Content
1. Workshop: Project Management (Scheduling of work), Literature research
2. Workshop: Teamwork, Conception of a product incl. evaluation of concepts
3. Workshop: Analysis and documentation of work results (incl. writing of scientific text and how to create a diagram)
4. Workshop: Presentation of scientific results

Course: Workshop 'Working Methods in Mechanical Engineering' (FAST - Leichtbau-technologie) [2114450]

Coordinators: F. Henning
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
- scientific writing
- literature research and citation techniques
- time management
- teamwork
- presentation and communication skills

Content
- Scientific working techniques
- Literature research
- Project management
- Time management
- Scientific elaborations
- Presentation techniques
- Communication skills

Course: Workshop 'Working Methods in Mechanical Engineering' (FAST - MOBIMA) [2114979]

Coordinators: M. Geimer
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
After succesful participation, studens can:

1. plan and schedule specific tasks under specified boundary conditions such as limited resources.
2. work task-oriented an motivated in a team
3. Discuss, explain and apply strategies for (literature-)research.
4. present technical information in text, oraly and with assistance of different media.
5. take into account principles of the scientific working in his own project work.

Content
Develop a new mobile machine with the steps:

- research state of the art
- develop performance specification
- frame out machine concept
- present results

The following scientific methods and tools are tought alongside:

- research techniques
- feedback
- presentation Media
- review processes
- abstracts

Media

- projector (Powerpoint)
- chart wall
- books/papers
- internet

Course: Workshop 'Working Methods in Mechanical Engineering' (FSM) [2158978]

Coordinators: M. Gabi
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
The student should be able

- To plan a concrete task under the considertion of specific regulations in a goal- and resource-oriented way.
- To find and chose scientific information according to pre-defined quality criteria.
- To write a precise and conclusive scientific abstract and to evaluate scientific papers.
- To present scientific information.
- To work in a team in a motivating and team-oriented way.

Content
Workshop 1: Self management, Problem solving, Work organisation

Workshop 2: Structuring of problems, Scientific research

Workshop 3: Scientific use of information

Workshop 4: Scientific presentations

Literature
Learning material:
Handout online on: https://ilias.rz.uni-karlsruhe.de/goto_rz-uka_cat_7815.html

Literature:

- SEIWERT, Lothar J.: Mehr Zeit für das Wesentliche: besseres Zeitmanagement mit der Seiwert-Methode konsequente Zeitplanung und effektive Arbeitsmethodik. Landsberg, Lech: Verlag Moderne Industrie, 12. Auflage, 1991.
- BECHER, Stephan: Schnell und erfolgreich studieren: Organisation – Zeitmanagement – Arbeitstechniken. Würzburg: Lexika Verlag / Krick Fachmedien GmbH + Co, 1998.
- KOEDER, Kurt W.: Studienmethodik: Selbstmanagement für Studienanfänger. München: Vahlen, 3. Auflage, 1998.
- FRANCK, Norbert; STARY, Joachim: Die Technik wissenschaftlichen Arbeitens. Paderborn u.a.:Verlag Ferdinand Schöningh, 15. Auflage, 2009.
- KARMASIN, Matthias; RIBING, Rainer: Die Gestaltung wissenschaftlicher Arbeiten. Wien: Facultas Verlags- und Buchhandels AG, 4. Auflage, 2009.
- KARMASIN, Matthias; RIBING, Rainer: Die Gestaltung wissenschaftlicher Arbeiten. Wien: Facultas Verlags- und Buchhandels AG, 4. Auflage, 2009.
- KRUSE, Otto: Keine Angst vor dem leeren Blatt. Frankfurt a.M.; New York: Campus Verlag, 12. Auflage, 2007.

- ROSSIG, Wolfram; PRÄTSCH, Joachim: Wissenschaftliche Arbeiten. Leitfaden für Haus- und Seminararbeiten, Bachelor- und Masterthesis, Diplom- und Magisterarbeiten, Dissertationen. Achim: BerlinDruck, 7. Auflage, 2008.

Please refer to the latest edition.

Course: Workshop 'Working Methods in Mechanical Engineering' (IAM-AWP) [2174987]

Coordinators: H. Seifert, P. Smyrek , M. Rank, P. Franke
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
The participants should be able to

- plan a concrete task under the consideration of specific regulations in a goal- and resource-oriented way.
- find and chose scientific information according to redefined quality criteria.
- write a precise and conclusive scientific abstract and to evaluate scientific papers.
- present scientific information conclusively.
- work in a team in a motivating and team-oriented way.

Content
Workshop 1: literature research
Workshop 2: literature review
Workshop 3: preparation for presentation
Workshop 4: presentation

Literature

- T. Reddy, Linden's Handbook of Batteries, McGraw-Hill Professional (2010)
- M. Winter, R.J. Brodd, What Are Batteries, Fuel Cells, and Supercapacitors? Chem. Rev. 104 (2004) 4245-4269
- J.L. Li, C. Daniel, D. Wood, Materials processing for lithium-ion batteries, J. Power Sources 196 (2011) 2452–2460

Course: Workshop 'Working Methods in Mechanical Engineering' (IAM-CMS, Gumbsch) [2182974]

Coordinators: P. Gumbsch, J. Gagel, K. Schulz
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
The student should be able

- to plan a concrete task under the considertion of specific regulations in a goal- and resource-oriented way.
- to find and chose scientific information according to pre-defined quality criteria.
- to write a precise and conclusive scientific abstract and to evaluate scientific papers.
- to present scientific information.
- to work in a team in a motivating and goal-oriented way.

Content
application of the lecture:
* project work in groups
* study of a particular given topic
* selection of material for presentation
* preparation of a presentation by poster or talk
* depending on the topic: Composition of a documentation

Literature
lecture notes
on-topic research paper
further literature

- SEIWERT, Lothar J.: Mehr Zeit für das Wesentliche: besseres Zeitmanagement mit der Seiwert-Methode konsequente Zeitplanung und effektive Arbeitsmethodik. Landsberg, Lech: Verlag Moderne Industrie, 12. Auflage, 1991.
- BECHER, Stephan: Schnell und erfolgreich studieren: Organisation – Zeitmanagement – Arbeitstechniken. Würzburg: Lexika Verlag / Krick Fachmedien GmbH + Co, 1998.
- KOEDER, Kurt W.: Studienmethodik: Selbstmanagement für Studienanfänger. München: Vahlen, 3. Auflage, 1998.
- FRANCK, Norbert; STARY, Joachim: Die Technik wissenschaftlichen Arbeitens. Paderborn u.a.:Verlag Ferdinand Schöningh, 15. Auflage, 2009.
- KARMASIN, Matthias; RIBING, Rainer: Die Gestaltung wissenschaftlicher Arbeiten. Wien: Facultas Verlags- und Buchhandels AG, 4. Auflage, 2009.
- KARMASIN, Matthias; RIBING, Rainer: Die Gestaltung wissenschaftlicher Arbeiten. Wien: Facultas Verlags- und Buchhandels AG, 4. Auflage, 2009.
- KRUSE, Otto: Keine Angst vor dem leeren Blatt. Frankfurt a.M.; New York: Campus Verlag, 12. Auflage, 2007.

- ROSSIG, Wolfram; PRÄTSCH, Joachim: Wissenschaftliche Arbeiten. Leitfaden für Haus- und Seminararbeiten, Bachelor- und Masterthesis, Diplom- und Magisterarbeiten, Dissertationen. Achim: BerlinDruck, 7. Auflage, 2008.

Please refer to the latest edition.

Course: Workshop 'Working Methods in Mechanical Engineering' (IAM-CMS, Nestler) [2182982]

Coordinators: B. Nestler, A. August
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
The student should be able

- to plan a concrete task under the considertion of specific regulations in a goal- and resource-oriented way.
- to find and chose scientific information according to pre-defined quality criteria.
- to write a precise and conclusive scientific abstract and to evaluate scientific papers.
- to present scientific information.
- to work in a team in a motivating and goal-oriented way.

Content
application of the lecture:
* project work in groups
* study of a particular given topic
* selection of material for presentation
* preparation of a presentation by poster or talk
* depending on the topic: Composition of a documentation

Media
books, research articles, web

Literature
lecture notes
on-topic research paper
further literature

- SEIWERT, Lothar J.: Mehr Zeit für das Wesentliche: besseres Zeitmanagement mit der Seiwert-Methode konsequente Zeitplanung und effektive Arbeitsmethodik. Landsberg, Lech: Verlag Moderne Industrie, 12. Auflage, 1991.
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- KOEDER, Kurt W.: Studienmethodik: Selbstmanagement für Studienanfänger. München: Vahlen, 3. Auflage, 1998.
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- KARMASIN, Matthias; RIBING, Rainer: Die Gestaltung wissenschaftlicher Arbeiten. Wien: Facultas Verlags- und Buchhandels AG, 4. Auflage, 2009.

- KRUSE, Otto: Keine Angst vor dem leeren Blatt. Frankfurt a.M.; New York: Campus Verlag, 12. Auflage, 2007.
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Please refer to the latest edition.

Course: Workshop 'Working Methods in Mechanical Engineering' (IAM-KWT) [2126980]

Coordinators: M. Hoffmann
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
The student should be able to plan a concrete task under the considertion of specific regulations in a goal- and resource-oriented way.
To find and chose scientific information according to pre-defined quality criteria.
To write a precise and conclusive scientific abstract and to evaluate scientific papers.
To present scientific information.
To work in a team in a motivating and team-oriented way.

Content
Workshop 1: Self management, Problem solving, Work organisation
Workshop 2: Structuring of problems, Scientific research
Workshop 3: Scientific use of information
Workshop 4: Scientific presentations

Course: Workshop 'Working Methods in Mechanical Engineering' (IAM-WBM) [2178981]

Coordinators: O. Kraft, P. Gruber
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes

- To treat a concrete task under the considertion of specific regulations in a goal- and resource-oriented way.
- To find and chose scientific information according to pre-defined quality criteria.
- To write a precise and conclusive scientific abstract and to evaluate scientific papers.
- To present scientific information.
- To work in a team in a motivating and team-oriented way.

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Content
Workshop 1: Literature research
Workshop 2: Writing of an abstact, Preparation of a poster
Workshop 3: Poster presentation, Preparation of a talk
Workshop 4: Presentation of the talk

Literature
Lecture notes

Course: Workshop 'Working Methods in Mechanical Engineering' (IAM-WK, Elsner) [2174976]

Coordinators: P. Elsner
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
strengthening of students' skills and abilities in
- scientific writing
- literature research and citation techniques
- time management
- teamwork
- presentation and communication skills

Content
On four afternoons at intervals of 2 weeks the students have to work on a project task in teams of 4. In the last workshop the teams have to present their results orally (presentation) and written (abstract, poster) and get feedback from the teching staff and the students from the other teams.

Course: Workshop 'Working Methods in Mechanical Engineering' (IAM-WK, Heilmaier) [2174986]

Coordinators: M. Heilmaier, K. von Klinski-Wetzel
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
The students are able to work target- and resources-oriented on a scientific and technical subject under specified conditions. They are able to research and select scientifical and technical informations according to set criteria. The students are able to present scientifical and technical informations in a clear, readable and convincing manner in a proposal. They can present scientifical and technical informations in a lecture-type form. They learn to work motivating and task-oriented in a team.

Content
Self-management, problem solving skills, work organization
Structuring problems, Research
Prepare and Present scientific information

Course: Workshop 'Working Methods in Mechanical Engineering' (IFAB) [2110968]

Coordinators: B. Deml
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
On completion of this workshop, the students are able

- to plan projects task- and resource-orientated,
- to apply creative techniques within a team,
- to find and to evaluate scientific data sources and to achieve needed information,
- to summarize researched information and work results in written form in a structured and concise style,
- to present scientific problems or results,
- to work task-oriented and constructively within a team.

Content
Workshop 1: Self management, Problem solving, Work organisation

Workshop 2: Structuring of problems, Scientific research

Workshop 3: Scientific use of information

Workshop 4: Scientific presentations

Literature
Handout and literature are available on ILIAS for download.

Course: Workshop 'Working Methods in Mechanical Engineering' (IFKM) [2134996]

Coordinators: T. Koch
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
After completion this lecture, the students are able
• to describe and to apply goal- and resource-oriented methods for the planning of a working task under defined conditions,
• to describe and apply methods for scientific research and the selection of relevant information according to defined criteria of quality,
• to evaluate the quality of a scientific source,
• to describe and apply empirical methods in mechanical engineering,
• to document scientific information in a clear, structured and convincing style in different formats (e.g. poster, expose, abstract, bachelor thesis),
• to evaluate the quality of a scientific text or poster,
• to present scientific information in a convincing and appealing style,
• to work in a heterogeneous team and to solve occuring conflicts.

Content
- Scientific working techniques
- Literature research
- Project management
- Time management
- Scientific elaborations
- Presentation techniques
- Communication skills

Course: Workshop 'Working Methods in Mechanical Engineering' (IFL) [2118973]

Coordinators: M. Mittwollen, S. Bolender
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	en

Learning Control / Examinations
s. module

Conditions
none

Recommendations
None.

Learning Outcomes
After completion of this lecture, the students are able

- to plan projects task and resource orientated,
- to apply creative technologies in a team,
- to find scientific data sources, evaluate their quality and extract suitable information,
- to summarize researched information and work results in written form in clear, structured and concise style,
- to present scientific problems or results in a convincing and appealing style,
- to work task-orientated and constructively within a team.

Content
In four workshops working methods like scientific-technical writing, literature research and quoting, time management, teamwork as well as presentation and communication methods are practiced and deepened.

Literature
None.

Course: Workshop 'Working Methods in Mechanical Engineering' (IFRT, Cheng) [2190975]

Coordinators: X. Cheng
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
Strengthening of students' skills and abilities in
- scientific writing
- literature research and citation techniques
- time management
- teamwork
- presentation and communication skills

Content
- Scientific working techniques
- Literature research
- Project management
- Time management
- Scientific elaborations
- Presentation techniques
- Communication skills

Course: Workshop 'Working Methods in Mechanical Engineering' I (IFRT, Stieglitz) [2190497]

Coordinators: V. Sánchez-Espinoza
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Recommendations
Knowledge in energy technology, mechanical engineering, thermal hydraulic, fluid dynamics is welcomed

Learning Outcomes
The students know:
- main principles for the design optimization of fission reactors
- importance of economics, safety and environmental aspects in the optimization of energy generation facilities

Content

- Energy generation options
- Nuclear power plants construction and operation
- Heat removal from reactor core
- Heat transfer mechanism in nuclear power plants
- Optimization potentials in nuclear power plants

Course: Workshop 'Working Methods in Mechanical Engineering' (IMI) [2128998]

Coordinators: J. Ovtcharova, Mitarbeiter
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
None.

Recommendations
None.

Learning Outcomes
Students become acquainted with working in a team and as well as gain experience in scientific research. They are able to analyze, to evaluate and to structure new information, as well as to abstract it within scientific reporting. Students develop independent concepts and case-based solutions and are able to present professionally the results, which have been worked out in the team. The students get a first insight into the approaches and ways of Product Lifecycle Management (PLM).

Content
Creativity techniques, presentation skills, communication techniques

Remarks
None.

Course: Workshop 'Working Methods in Mechanical Engineering' (IMT) [2142975]

Coordinators: M. Worgull
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
Competences in

- Teamwork
- Working with limitation of time
- Scientific investigation
- Scientific citation
- Scientific writing
- Presentation

Content
Within the frame of a scientific conference the contents from the corresponding lesson will be implemented in a practical way.
The students have to organise a scientific conference by themself. The contributions have to prepared by the students and will be presented within the frame of abstracts, conference articles, posters, and presentations.
1. part of the workshop - Organisation of a conference

- Structure of a conference
- Generation of workgroups - Committees
- Exchange of Informations between workgroups
- Decision-making based on the information available
- Decision-making based under limitation of time
- Gerartion of technical progam, budget, flyer etc. of the conference
- Definition of critera for abstracts - communication of criteria

2. partl of the workshop - Investigation and writing of abstracts

- Investigation in Literatur / Patent Database
- Citation of scientific literature
- Writing of abstracts
- Evaluation of abstracts

3. part of the workshop - Writing of scientific conference contributions

- Structure of a scientific article
- Rules for scientific writing - style

- Citation - Sources and their citation
- Design of scientifi posters
- Design of a scientific presentation

4. part of the workshop - Moderation and presentation

- Presentation of the results of the workshop - oral presentations
- Presentation of posters
- Moderation of the confernce

Media
Computer with internet access

Literature
Script for the Workshop - Fundamentals of scientific writing, poster design, moderation and presentation were summerized in a kind of workshop guide.

Course: Workshop 'Working Methods in Mechanical Engineering' (IPEK, Albers) [2146971]

Coordinators: A. Albers
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
The student should be able to ...

- plan a concrete task under the considertion of specific regulations in a goal- and resource-oriented way.
- find and chose scientific information according to pre-defined quality criteria.
- write a precise and conclusive scientific abstract and to evaluate scientific papers.
- present scientific information.
- work in a team in a motivating and team-oriented way.

Content
Content
1st Workshop:
Self- Organisation of the research task, division of labor within the team
2nd Workshop:
Introduction to creativity and application of these techniques in the team, hosted by appropriate experts.
3rd Workshop:
Introduction to methods for making and applying this as a team, hosted by appropriate experts.
4th Workshop:
Present scientific information and develop a presentation.

Media
Computer
Beamer
Flipchart
Whiteboard/ methaplan wall

Literature
SEIWERT, Lothar J.: Mehr Zeit für das Wesentliche: besseres Zeitmanagement mit der Seiwert-Methode konsequente Zeitplanung und effektive Arbeitsmethodik. Landsberg, Lech: Verlag Moderne Industrie, 12. Auflage, 1991.
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Please refer to the latest edition.

Course: Workshop 'Working Methods in Mechanical Engineering' (IPEK, Matthiesen) [2146972]

Coordinators: S. Matthiesen
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
The student is able to ...

- plan a concrete task under the considertion of specific regulations in a goal- and resource-oriented way.
- find and chose scientific information according to pre-defined quality criteria.
- write a precise and conclusive scientific abstract and to evaluate scientific papers.
- present scientific information.
- work in a team in a motivating and team-oriented way.

Content
1st Workshop:
Self- Organisation of the research task, division of labor within the team
2nd Workshop:
Introduction to creativity and application of these techniques in the team, hosted by appropriate experts.
3rd Workshop:
Introduction to methods for making and applying this as a team, hosted by appropriate experts.
4th Workshop:
Present scientific information and develop a presentation.

Media
Computer
Beamer
Flipchart
Whiteboard
Methaplan wall

Literature
SEIWERT, Lothar J.: Mehr Zeit für das Wesentliche: besseres Zeitmanagement mit der Seiwert-Methode konsequente Zeitplanung und effektive Arbeitsmethodik. Landsberg, Lech: Verlag Moderne Industrie, 12. Auflage, 1991.
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KOEDER, Kurt W.: Studienmethodik: Selbstmanagement für Studienanfänger. München: Vahlen, 3. Auflage, 1998.
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KARMASIN, Matthias; RIBING, Rainer: Die Gestaltung wissenschaftlicher Arbeiten. Wien: Facultas Verlags- und Buchhandels AG, 4. Auflage, 2009.
KRUSE, Otto: Keine Angst vor dem leeren Blatt. Frankfurt a.M.; New York: Campus Verlag, 12. Auflage, 2007.
ROSSIG, Wolfram; PRÄTSCH, Joachim: Wissenschaftliche Arbeiten. Leitfaden für Haus- und Seminararbeiten, Bachelor- und Masterthesis, Diplom- und Magisterarbeiten, Dissertationen. Achim: BerlinDruck, 7. Auflage, 2008.
Please refer to the latest edition.

Course: [2154992]

Coordinators: B. Frohnapfel
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
After completing this workshop the students are able:
- to coordinate and to work constructive within changing teams,
- to find and evaluate scientific data sources and to keep records of needed information,
- to develop expertise and contribute it to the team,
- to present scientific results,
- to summarize results in written form

Content
Provide integrated concepts for power supply in different regions

Media
Powerpoint, flip chart, white board

Course: Workshop 'Working Methods in Mechanical Engineering' (ITM, Böhlke) [2162983]

Coordinators: T. Böhlke, Mitarbeiter
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Recommendations
None.

Learning Outcomes
The students can

- apply the theoretical concepts of stress concentrations in elastic components
- perform a finite-element-analysis for computing the stresses within an elastic component
- write an abstract of the problem and their solution
- write a short report about the problem and their solution using the document preparing system LaTeX and they can use LaTeX-Templates
- give a short presentation about their problem and solution

Content
Solving a problem of approximation methods applied to stress concentration in elastic components

Course: Workshop 'Working Methods in Mechanical Engineering' (ITM, Fidlin) [2162995]

Coordinators: A. Fidlin
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
Strengthening of students' skills and abilities in
- scientific writing
- literature research and citation techniques
- time management
- teamwork
- presentation and communication skills

Content
- Scientific working techniques
- Literature research
- Project management
- Time management
- Scientific elaborations
- Presentation techniques
- Communication skills

Course: Workshop 'Working Methods for Mechanical Engineering' (ITM, Proppe) [2162994]

Coordinators: C. Proppe
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
None

Learning Outcomes
Strengthening of students' skills and abilities in
- scientific writing
- literature research and citation techniques
- time management
- teamwork
- presentation and communication skills

Content
1. Teamwork - Literature Research - Time and Project Management

2. Communication and Feedback - Writing Skills

3. Self-management - Presentation Skills

Course: Workshop 'Working Methods in Mechanical Engineering' (ITM, Seemann) [2162996]

Coordinators: W. Seemann
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
Strengthening of students' skills and abilities in
- scientific writing
- literature research and citation techniques
- time management
- teamwork
- presentation and communication skills

Content
- Scientific working techniques
- Literature research
- Project management
- Time management
- Scientific elaborations
- Presentation techniques
- Communication skills

Course: Workshop 'Working Methods in Mechanical Engineering' (ITS) [2170972]

Coordinators: H. Bauer
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
The students are able to:

- analyse scientific-technical articles
- conduct literature research
- correclty cite articles
- work together in a team
- manage a project within a given time frame
- present relations in a clear and comprehensible way

Content

Course: Workshop 'Working Methods in Mechanical Engineering' (ITT) [2166991]

Coordinators: U. Maas
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Recommendations
None

Learning Outcomes
The student should be able

- To plan a concrete task under the considertion of specific regulations in a goal- and resource-oriented way.
- To find and chose scientific information according to pre-defined quality criteria.
- To write a precise and conclusive scientific abstract and to evaluate scientific papers.
- To present scientific information.
- To work in a team in a motivating and team-oriented way.

Content

- Self management, Problem solving, Work organisation
- Structuring of problems, Scientific research
- Scientific use of information
- Scientific presentations

Media
None

Literature
Learning material:
Handout online in Ilias
Literature:

- SEIWERT, Lothar J.: Mehr Zeit für das Wesentliche: besseres Zeitmanagement mit der Seiwert-Methode konsequente Zeitplanung und effektive Arbeitsmethodik. Landsberg, Lech: Verlag Moderne Industrie, 12. Auflage, 1991.
- BECHER, Stephan: Schnell und erfolgreich studieren: Organisation – Zeitmanagement – Arbeitstechniken. Würzburg: Lexika Verlag / Krick Fachmedien GmbH + Co, 1998.
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Please refer to the latest edition.

Remarks
None

Course: Workshop 'Working Methods in Mechanical Engineering' (MRT) [2138997]

Coordinators: C. Stiller
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Learning Outcomes
Strengthening of students' skills and abilities in
- scientific writing
- literature research and citation techniques
- time management
- teamwork
- presentation and communication skills

Content
- Scientific working techniques
- Literature research
- Project management
- Time management
- Scientific elaborations
- Presentation techniques
- Communication skills

Course: Workshop 'Working Methods in Mechanical Engineering' (WBK, Fleischer) [2150989]

Coordinators: J. Fleischer
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Recommendations
None

Learning Outcomes
The students are able to. . .

- find appropriate data sources, evaluate and extract information.
- apply a predetermined citation style correctly.
- summarize information and results shortly and concisely in a written form.
- to design visual preparations of scientific problems or results and to give an oral presentation.
- to work in task-oriented cooperation as a team.

Content
1. Workshop: Working in a team, creativity techniques, critise and accept critism
2. Workshop: Presentation, literature research, working in a team
3. Workshop: Presentation, scientific writing, working in a team
4. Workshop: Presentation

Media
The slides will be provided after each workshop.

Literature
Lecture Slides

Remarks
None

Course: Workshop 'Working Methods in Mechanical Engineering' (WBK, Lanza) [2150988]

Coordinators: G. Lanza
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	en

Learning Control / Examinations
s. module

Conditions
none

Recommendations
None

Learning Outcomes
The students are able to...

- find appropriate data sources, evaluate and extract information.
- apply a predetermined citation style correctly.
- summarize information and results shortly and concisely in a written form.
- to design visual preparations of scientific problems or results and to make an oral presentation.
- to work in task-oriented cooperation as a team.

Content
1. Workshop: Literature research, citation styles
2. Workshop: Poster presentation, Project management, Production technology related content
3. Workshop: Scientific publication, production aspects in a practical manner
4. Workshop: Presentation, including video analysis

Media
The slides will be provided after each workshop.

Literature
Lecture Slides

Remarks
None

Course: Workshop 'Working Methods in Mechanical Engineering' (WBK, Schulze) [2150987]

Coordinators: V. Schulze
Part of the modules: Soft Skills (p. 31)[BSc-Modul 16, SQL (2016)]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
s. module

Conditions
none

Recommendations
None

Learning Outcomes
The students are able to...

- find appropriate data sources, evaluate and extract information.
- apply a predetermined citation style correctly.
- summarize information and results shortly and concisely in a written form.
- to design visual preparations of scientific problems or results and to make an oral presentation.
- to work in task-oriented cooperation as a team.

Content
1. Workshop: Working in a team, literature research
2. Workshop: Presentation, scientific writing, literature research, working in a team
3. Workshop: Scientific writing, working in a team
4. Workshop: Presentation

Media
The slides will be provided after each workshop.

Literature
Lecture Slides

Remarks
None

4.2 Courses in English

Module: Lectures in English (B.Sc.) []

Coordination:
Degree programme: Bachelorstudiengang Maschinenbau (B.Sc.)
Subject:

ECTS Credits	Cycle	Duration

Courses in module

ID	Course	Hours per week C/E/T	Term	CP	Responsible Lecturer(s)
2110969	Working Methods in Mechanical Engineering (p. 41)	1	S	2	B. Deml
2113809	Automotive Engineering I (eng.) (p. 59)	4	W	8	F. Gauterin, M. Gießler
2161224	Machine Dynamics (p. 72)	3	S	5	C. Proppe
23211	Materials and Devices in Electrical Engineering (p. 83)	2	W	3	A. Weber
2145186	Mechanical Design I (p. 75)	4	W	4	A. Albers, N. Burkardt
2114856	Vehicle Ride Comfort & Acoustics I (eng.) (p. 56)	2	S	4	F. Gauterin
2114857	Vehicle Ride Comfort & Acoustics II (eng.) (p. 57)	2	S	4	F. Gauterin
23448	Space-born Microwave Radiometry - Advanced Methods and Applications (p. 97)	2	S	3	H. Süß
23405	Radar Systems Engineering (p. 96)	2	W	3	W. Wiesbeck
23263	Electromagnetics and Numerical Calculation of Fields (p. 53)	3	W	4,5	O. Dössel
2169453	Thermal Turbomachines I (p. 110)	3	W	6	H. Bauer
2189404	A holistic approach to power plant management (p. 49)	2	W	4	M. Seidl, R. Stieglitz
2137308	Machine Vision (p. 70)	4	W	8	C. Stiller, M. Lauer
3118095	Global Logistics (p. 61)	2	S	4	K. Furmans, T. Kivelä, K. Dörr

Learning Control / Examinations

Conditions
None.

Learning Outcomes

Content

Workload

Remarks
The integration of these lectures into modules is described in the respective modules.

5 Major Fields

SP 02: Powertrain Systems

ID	Cat	Course	Lecturer	h	CP	Term
2113077	K	Drive Train of Mobile Machines (p. 183)	M. Geimer, M. Scherer, D. Engelmann	3	4	W
2146180	K	Powertrain Systems Technology A: Automotive Systems (p. 185)	A. Albers, S. Ott	2	4	S
2145150	K	Powertrain Systems Technology B: Stationary Machinery (p. 186)	A. Albers, S. Ott	2	4	W
2163111	K	Dynamics of the Automotive Drive Train (p. 219)	A. Fidlin	4	5	W
2145181	E	Applied Tribology in Industrial Product Development (p. 182)	A. Albers, B. Lorentz	2	4	W
2146208	E	Dimensioning and Optimization of Power Train System (p. 199)	H. Faust	2	4	S
2162235	E	Introduction into the multi-body dynamics (p. 224)	W. Seemann	3	5	S
2117500	E	Energy efficient intralogistic systems (p. 230)	M. Braun, F. Schönung	2	4	W
23321	E	Hybrid and Electric Vehicles (p. 275)	M. Doppelbauer, M. Schiefer	3	4	W
2118183	E	IT-Fundamentals of Logistics (p. 285)	F. Thomas	2	4	S
2145184	E	Leadership and Management Development (p. 295)	A. Ploch	2	4	W
2161224	E	Machine Dynamics (p. 301)	C. Proppe	3	5	S
2162220	E	Machine Dynamics II (p. 302)	C. Proppe	2	4	W
2141865	E	Novel actuators and sensors (p. 324)	M. Kohl, M. Sommer	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 328)	F. Zacharias	2	4	W/S
2113072	E	Development of Oil-Hydraulic Powertrain Systems (p. 345)	G. Geerling, S. Becker	2	4	W
2145182	E	Project management in Global Product Engineering Structures (p. 347)	P. Gutzmer	2	4	W
2150683	E	Control Technology (p. 371)	C. Gönnheimer	2	4	S
2146198	E	Strategic product development - identification of potentials of innovative products (p. 373)	A. Siebe	2	4	S
2146192	E	Sustainable Product Engineering (p. 377)	K. Ziegahn	2	4	S
2181114	E	Tribology (p. 393)	M. Dienwiebel	5	8	W
2133113	E	Combustion Engines I (p. 397)	H. Kubach, T. Koch	3	4	W
2181711	E	Failure of structural materials: deformation and fracture (p. 400)	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 10: Engineering Design

ID	Cat	Course	Lecturer	h	CP	Term
2146180	K	Powertrain Systems Technology A: Automotive Systems (p. 185)	A. Albers, S. Ott	2	4	S
2145150	K	Powertrain Systems Technology B: Stationary Machinery (p. 186)	A. Albers, S. Ott	2	4	W
2146190	K	Lightweight Engineering Design (p. 290)	A. Albers, N. Burkardt	2	4	S
2145181	E	Applied Tribology in Industrial Product Development (p. 182)	A. Albers, B. Lorentz	2	4	W
2113079	E	Design and Development of Mobile Machines (p. 198)	M. Geimer, J. Siebert	2	4	W
2113809	E	Automotive Engineering I (eng.) (p. 259)	F. Gauterin, M. Gießler	4	8	W
2147175	E	CAE-Workshop (p. 210)	A. Albers, Assistenten	3	4	W/S
2161229	EM	Designing with numerical methods in product development (p. 218)	E. Schnack	2	4	W
2110050	E	Vehicle Ergonomics (p. 241)	T. Heine	2	4	S
2149657	E	Manufacturing Technology (p. 251)	V. Schulze, F. Zanger	6	8	W
2113805	E	Automotive Engineering I (p. 258)	F. Gauterin, H. Unrau	4	8	W
2113814	E	Fundamentals for Design of Motor-Vehicles Bodies I (p. 268)	H. Bardehle	1	2	W
2114840	E	Fundamentals for Design of Motor-Vehicles Bodies II (p. 269)	H. Bardehle	1	2	S
2113812	E	Fundamentals in the Development of Commercial Vehicles I (p. 270)	J. Zürn	1	2	W
2114844	E	Fundamentals in the Development of Commercial Vehicles II (p. 271)	J. Zürn	1	2	S
2113810	E	Fundamentals of Automobile Development I (p. 272)	R. Frech	1	2	W
2114842	E	Fundamentals of Automobile Development II (p. 273)	R. Frech	1	2	S
2150601	E	Integrative Strategies in Production and Development of High Performance Cars (p. 283)	K. Schlichtenmayer	2	4	S
2174571	E	Design with Plastics (p. 289)	M. Liedel	2	4	S
2145184	E	Leadership and Management Development (p. 295)	A. Ploch	2	4	W
2110017	E	Leadership and Conflict Management (in German) (p. 300)	H. Hatzl	2	4	S
2105014	E (P)	Laboratory mechatronics (p. 314)	C. Stiller, M. Lorch, W. Seemann	3	4	W
2114860	E	Principles of Whole Vehicle Engineering II (p. 339)	R. Frech	1	2	S
2113072	E	Development of Oil-Hydraulic Powertrain Systems (p. 345)	G. Geerling, S. Becker	2	4	W
2145182	E	Project management in Global Product Engineering Structures (p. 347)	P. Gutzmer	2	4	W
2149667	E	Quality Management (p. 349)	G. Lanza	2	4	W
2117061	E	Safety Engineering (p. 363)	H. Kany	2	4	W
2146198	E	Strategic product development - identification of potentials of innovative products (p. 373)	A. Siebe	2	4	S
2146192	E	Sustainable Product Engineering (p. 377)	K. Ziegahn	2	4	S
2158107	E	Technical Acoustics (p. 379)	M. Gabi	2	4	S
2146179	E	Technical Design in Product Development (p. 385)	M. Schmid	2	4	S

ID	Cat	Course	Lecturer	h	CP	Term
2149902	E	Machine Tools and Industrial Handling (p. 410)	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 12: Automotive Technology

ID	Cat	Course	Lecturer	h	CP	Term
2113809	K	Automotive Engineering I (eng.) (p. 259)	F. Gauterin, M. Gießler	4	8	W
2113805	K	Automotive Engineering I (p. 258)	F. Gauterin, H. Unrau	4	8	W
2133132	E	Alternative Powertrain for Automobiles (p. 181)	K. Noreikat, H. Kubach	2	4	W
2146180	E	Powertrain Systems Technology A: Automotive Systems (p. 185)	A. Albers, S. Ott	2	4	S
2146208	E	Dimensioning and Optimization of Power Train System (p. 199)	H. Faust	2	4	S
2150904	E	Automated Manufacturing Systems (p. 200)	J. Fleischer	6	8	S
2163111	E	Dynamics of the Automotive Drive Train (p. 219)	A. Fidlin	4	5	W
2113807	E	Handling Characteristics of Motor Vehicles I (p. 239)	H. Unrau	2	4	W
2114838	E	Handling Characteristics of Motor Vehicles II (p. 240)	H. Unrau	2	4	S
2110050	E	Vehicle Ergonomics (p. 241)	T. Heine	2	4	S
2113806	E	Vehicle Comfort and Acoustics I (p. 242)	F. Gauterin	2	4	W
2114825	E	Vehicle Comfort and Acoustics II (p. 244)	F. Gauterin	2	4	S
2113102	E	Vehicle Lightweight design – Strategies, Concepts, Materials (p. 246)	F. Henning	2	4	W
2113816	E	Vehicle Mechatronics I (p. 247)	D. Ammon	2	4	W
2114845	E	Tires and Wheel Development for Passenger Cars (p. 248)	G. Leister	2	4	S
2138340	E	Automotive Vision (eng.) (p. 249)	C. Stiller, M. Lauer	3	6	S
2114053	E	Composite Manufacturing – Polymers, Fibers, Semi-Finished Products, Manufacturing Technologies (p. 250)	F. Henning	2	4	S
2114835	E	Automotive Engineering II (p. 260)	H. Unrau	2	4	S
2134138	E	Fundamentals of catalytic exhaust gas aftertreatment (p. 264)	E. Lox, H. Kubach, O. Deutschmann, J. Grunwaldt	2	4	S
2113814	E	Fundamentals for Design of Motor-Vehicles Bodies I (p. 268)	H. Bardehle	1	2	W
2114840	E	Fundamentals for Design of Motor-Vehicles Bodies II (p. 269)	H. Bardehle	1	2	S
2113812	E	Fundamentals in the Development of Commercial Vehicles I (p. 270)	J. Zürn	1	2	W
2114844	E	Fundamentals in the Development of Commercial Vehicles II (p. 271)	J. Zürn	1	2	S
2113810	E	Fundamentals of Automobile Development I (p. 272)	R. Frech	1	2	W
2114842	E	Fundamentals of Automobile Development II (p. 273)	R. Frech	1	2	S
23321	E	Hybrid and Electric Vehicles (p. 275)	M. Doppelbauer, M. Schiefer	3	4	W
2153425	E	Industrial aerodynamics (p. 278)	T. Breitling, B. Frohnapfel	2	4	W
2150601	E	Integrative Strategies in Production and Development of High Performance Cars (p. 283)	K. Schlichtenmayer	2	4	S
2146190	E	Lightweight Engineering Design (p. 290)	A. Albers, N. Burkardt	2	4	S
2115808	E (P)	Motor Vehicle Laboratory (p. 291)	M. Frey	2	4	W/S

ID	Cat	Course	Lecturer	h	CP	Term
2182642	E	Laser in automotive engineering (p. 294)	J. Schneider	2	4	S
2149669	E	Materials and Processes for Body Lightweight Construction in the Automotive Industry (p. 305)	D. Steegmüller, S. Kienzle	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 328)	F. Zacharias	2	4	W/S
2114860	E	Principles of Whole Vehicle Engineering II (p. 339)	R. Frech	1	2	S
2123364	E	Product, Process and Resource Integration in the Automotive Industry (p. 342)	S. Mbang	3	4	S
2115817	E	Project Workshop: Automotive Engineering (p. 344)	F. Gauterin, M. Gießler, M. Frey	3	6	W/S
2113072	E	Development of Oil-Hydraulic Powertrain Systems (p. 345)	G. Geerling, S. Becker	2	4	W
2145182	E	Project management in Global Product Engineering Structures (p. 347)	P. Gutzmer	2	4	W
2162256	E	Computational Vehicle Dynamics (p. 351)	C. Proppe	2	4	S
5012053	E	Seminar for Automobile and Traffic History (p. 362)	T. Meyer	2	4	W/S
2185264	E	Simulation in product development process (p. 366)	T. Böhlke	2	4	W
2146198	E	Strategic product development - identification of potentials of innovative products (p. 373)	A. Siebe	2	4	S
2146192	E	Sustainable Product Engineering (p. 377)	K. Ziegahn	2	4	S
2114856	E	Vehicle Ride Comfort & Acoustics I (eng.) (p. 243)	F. Gauterin	2	4	S
2114857	E	Vehicle Ride Comfort & Acoustics II (eng.) (p. 245)	F. Gauterin	2	4	S
2133113	E	Combustion Engines I (p. 397)	H. Kubach, T. Koch	3	4	W
2138336	E	Behaviour Generation for Vehicles (p. 398)	C. Stiller, M. Werling	2	4	S
2149655	E	Gear Cutting Technology (p. 402)	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 13: Strength of Materials / Continuum Mechanics

ID	Cat	Course	Lecturer	h	CP	Term
2161252	K	Advanced Methods in Strength of Materials (p. 274)	T. Böhlke	4	4	W
2161254	K	Mathematical Methods in Strength of Materials (p. 308)	T. Böhlke	3	5	W
2147175	E	CAE-Workshop (p. 210)	A. Albers, Assistenten	3	4	W/S
2162282	E	Introduction to the Finite Element Method (p. 221)	T. Böhlke	4	5	S
2161206	E	Mathematical Methods in Dynamics (p. 307)	C. Proppe	2	5	W
2161123	E	Computational Homogenization on Digital Image Data (p. 213)	M. Schneider	2	6	W
2162216	E	Computerized Multibody Dynamics (p. 352)	W. Seemann	2	4	S
2181711	E	Failure of structural materials: deformation and fracture (p. 400)	P. Gumbsch, D. Weygand, O. Kraft	3	4	W

Conditions: The number of places for this major field is limited. The institutes decides about registration.
Recommendations: Recommended compulsory elective subjects:

- 2161206 Mathematical Methods in Dynamics
- 2161254 Mathematical Methods in Strength of Materials
- 2174576 Systematic Materials Selection

Learning Outcomes: After having finished this major field the students can

- list mportant concepts and models of continuum mechanics
- analyse and evaluate models for describing the material behaviour
- apply these models in given problems

Remarks:

SP 15: Fundamentals of Energy Technology

ID	Cat	Course	Lecturer	h	CP	Term
2130927	KP	Fundamentals of Energy Technology (p. 257)	A. Badea, X. Cheng	5	8	S
2189903	K	Introduction to Nuclear Energy (p. 222)	X. Cheng	2	4	W
2166538	K	Fundamentals of Combustion II (p. 267)	U. Maas	2	4	S
2157432	K	Hydraulic Fluid Machinery (p. 277)	B. Pritz	4	8	S
2190411	E	Selected Problems of Applied Reactor Physics and Exercises (p. 196)	R. Dagan	2	4	S
2133108	EM	Fuels and Lubricants for Combustion Engines (p. 205)	B. Kehrwald, H. Kubach	2	4	W
2169459	EM (P)	CFD-Lab using Open Foam (p. 211)	R. Koch	3	4	W
2157444	EM (P)	Introduction to numerical fluid dynamics (p. 225)	B. Pritz	2	4	W
2117500	E	Energy efficient intralogistic systems (p. 230)	M. Braun, F. Schönung	2	4	W
2189487	E	Energy Storage and Network Integration (p. 231)	R. Stieglitz, W. Jaeger, Jäger, Noe	2	4	W
2129901	E	Energy Systems I: Renewable Energy (p. 233)	R. Dagan	3	6	W
2154200	E	Gasdynamics (p. 255)	F. Magagnato	2	4	W
2171487	E (P)	Laboratory Exercise in Energy Technology (p. 296)	H. Bauer, U. Maas, H. Wirbser	3	4	W/S
2134134	EM	Analysis tools for combustion diagnostics (p. 317)	J. Pfeil	2	4	S
2142897	E	Microenergy Technologies (p. 318)	M. Kohl	2	4	S
2169458	EM	Numerical simulation of reacting two phase flows (p. 326)	R. Koch	2	4	W
2153441	E	Numerical Fluid Mechanics (p. 327)	F. Magagnato	2	4	W
23737	E	Photovoltaics (p. 329)	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. 330)	R. Dagan, Dr. Volker Metz	1	2	W
2171488	E (P)	Workshop on computer-based flow measurement techniques (p. 337)	H. Bauer	3	4	W/S
2189400	E	Solar Thermal Energy Systems (p. 369)	R. Dagan	2	4	W
2189910	E	Flows and Heat Transfer in Energy Technology (p. 374)	X. Cheng	2	4	W
2146192	EM	Sustainable Product Engineering (p. 377)	K. Ziegahn	2	4	S
2158107	EM	Technical Acoustics (p. 379)	M. Gabi	2	4	S
2169472	E	Thermal Solar Energy (p. 388)	R. Stieglitz	2	4	W
2169453	EM	Thermal Turbomachines I (p. 390)	H. Bauer	3	6	W
2133113	EM	Combustion Engines I (p. 397)	H. Kubach, T. Koch	3	4	W
2157381	E	Windpower (p. 412)	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 17: Information Management

ID	Cat	Course	Lecturer	h	CP	Term
2123900	K	I4.0 Systems platform (p. 286)	J. Ovtcharova, T. Maier	4	6	W/S
2121350	K	Product Lifecycle Management (p. 340)	J. Ovtcharova, T. Maier	3	4	W
2121001	K	Integrated Information Systems for engineers (p. 383)	J. Ovtcharova	3	4	S
2122300	E	Agile product innovation management - value-driven planning of new products (p. 180)	R. Kläger	2	4	S
2123358	E/P (P)	CATIA CAD training course (p. 208)	J. Ovtcharova	2	2	W/S
2123357	E/P (P)	CAD-NX training course (p. 209)	J. Ovtcharova	2	2	W/S
2147175	E	CAE-Workshop (p. 210)	A. Albers, Assistenten	3	4	W/S
2122014	E	Information Engineering (p. 279)	J. Ovtcharova	2	3	S
2118094	E	Information Systems in Logistics and Supply Chain Management (p. 280)	C. Kilger	2	4	S
2118183	E	IT-Fundamentals of Logistics (p. 285)	F. Thomas	2	4	S
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 328)	F. Zacharias	2	4	W/S
2122376	E	PLM for Product Development in Mechatronics (p. 332)	M. Eigner	2	4	S
2121357	E	PLM-CAD Workshop (p. 333)	J. Ovtcharova	4	4	W/S
2123364	E	Product, Process and Resource Integration in the Automotive Industry (p. 342)	S. Mbang	3	4	S
2145182	E	Project management in Global Product Engineering Structures (p. 347)	P. Gutzmer	2	4	W
2117062	E	Supply chain management (p. 376)	K. Alicke	4	6	W
2146192	E	Sustainable Product Engineering (p. 377)	K. Ziegahn	2	4	S
2123375	E	Virtual Reality Laboratory (p. 404)	J. Ovtcharova	3	4	W/S

Conditions:
Recommendations: Attendance of the course Product Lifecycle Management [2121350] as elective module is recommended.
Learning Outcomes: The students should:
Understand the relevance of information management in product development in consideration of increasing product and process complexity.
Gain basic knowledge in handling information, which is generated by product development activities along the lifecycle.
Remarks:

SP 18: Information Technology

ID	Cat	Course	Lecturer	h	CP	Term
2105016	K	Computational Intelligence (p. 214)	R. Mikut, W. Jakob, M. Reischl	2	4	W
2106014	K	Data Analytics for Engineers (p. 215)	R. Mikut, M. Reischl, J. Stegmaier	3	5	S
2137309	K	Digital Control (p. 217)	M. Knoop	2	4	W
2137308	K	Machine Vision (p. 299)	C. Stiller, M. Lauer	4	8	W
2138326	K	Measurement II (p. 316)	C. Stiller	2	4	S
2106002	K	Computer Engineering (p. 381)	M. Lorch, H. Keller	3	6	S
2138340	E	Automotive Vision (eng.) (p. 249)	C. Stiller, M. Lauer	3	6	S
2114092	E	BUS-Controls (p. 207)	M. Geimer	2	4	S
2118094	E	Information Systems in Logistics and Supply Chain Management (p. 280)	C. Kilger	2	4	S
2105022	E	Information Processing in Mechatronic Systems (p. 281)	M. Kaufmann	2	4	W
24102	E	Information Processing in Sensor Networks (p. 282)	U. Hanebeck, Christiof Chlebek	3	4	W
2118183	E	IT-Fundamentals of Logistics (p. 285)	F. Thomas	2	4	S
2105014	E (P)	Laboratory mechatronics (p. 314)	C. Stiller, M. Lorch, W. Seemann	3	4	W
2134137	E	Engine measurement techniques (p. 323)	S. Bernhardt	2	4	S
2137306	E (P)	Lab Computer-aided methods for measurement and control (p. 336)	C. Stiller, M. Spindler	3	4	W
2169550	E	Reliability Engineering 1 (p. 353)	A. Konnov	2	3	S
2150683	E	Control Technology (p. 371)	C. Gönnheimer	2	4	S
2138336	E	Behaviour Generation for Vehicles (p. 398)	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 24: Energy Converting Engines

ID	Cat	Course	Lecturer	h	CP	Term
2157432	K	Hydraulic Fluid Machinery (p. 277)	B. Pritz	4	8	S
2169453	K	Thermal Turbomachines I (p. 390)	H. Bauer	3	6	W
2133113	K	Combustion Engines I (p. 397)	H. Kubach, T. Koch	3	4	W
22527	E	Design of a jet engine combustion chamber (p. 197)	N. Zarzalis	2	6	W
2133108	E	Fuels and Lubricants for Combustion Engines (p. 205)	B. Kehrwald, H. Kubach	2	4	W
2157444	E (P)	Introduction to numerical fluid dynamics (p. 225)	B. Pritz	2	4	W
2154446	E	Experimental Fluid Mechanics (p. 237)	J. Kriegseis	2	4	S
2114093	E	Fluid Technology (p. 254)	M. Geimer, M. Scherer, L. Brinkschulte	4	5	W
2154200	E	Gasdynamics (p. 255)	F. Magagnato	2	4	W
2134138	E	Fundamentals of catalytic exhaust gas aftertreatment (p. 264)	E. Lox, H. Kubach, O. Deutschmann, J. Grunwaldt	2	4	S
2165515	E	Fundamentals of Combustion I (p. 266)	U. Maas	2	4	W
2166538	E	Fundamentals of Combustion II (p. 267)	U. Maas	2	4	S
2153441	E	Numerical Fluid Mechanics (p. 327)	F. Magagnato	2	4	W
2113072	E	Development of Oil-Hydraulic Powertrain Systems (p. 345)	G. Geerling, S. Becker	2	4	W
2169550	E	Reliability Engineering 1 (p. 353)	A. Konnov	2	3	S
2158107	E	Technical Acoustics (p. 379)	M. Gabi	2	4	S
2170476	E	Thermal Turbomachines II (p. 391)	H. Bauer	3	6	S
2170478	E	Turbo Jet Engines (p. 396)	H. Bauer, A. Schulz	2	4	S
2169462	EM	Turbine and compressor Design (p. 395)	H. Bauer, A. Schulz	2	4	W
2157381	E	Windpower (p. 412)	N. Lewald	2	4	W
2153438	E	Vortex Dynamics (p. 413)	J. Kriegseis	2	4	W
2134153	E	Boosting of Combustion Engines (p. 192)	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 26: Materials Science and Engineering

ID	Cat	Course	Lecturer	h	CP	Term
2173553	K	Materials Science and Engineering III (p. 408)	M. Heilmaier, K. Lang	5	8	W
2181740	E	Atomistic simulations and molecular dynamics (p. 189)	C. Brandl, P. Gumbsch	2	4	S
2194643	E	Constitution and Properties of Wear resistant materials (p. 190)	S. Ulrich	2	4	S
2177601	EM	Constitution and Properties of Protective Coatings (p. 191)	S. Ulrich	2	4	W
2181708	E/P	Biomechanics: design in nature and inspired by nature (p. 206)	C. Mattheck	3	4	W
2181731	EM	Fatigue of Welded Components and Structures (p. 235)	M. Farajian, P. Gumbsch,	2	4	W
2175590	E (P)	Metallographic Lab Class (p. 238)	U. Hauf	3	4	W/S
2174575	E	Foundry Technology (p. 256)	C. Wilhelm	2	4	S
2193010	E	Basic principles of powder metallurgical and ceramic processing (p. 263)	G. Schell, R. Oberacker	2	4	W
2125757	E	Introduction to Ceramics (p. 287)	M. Hoffmann	4	6	W
2174571	E	Design with Plastics (p. 289)	M. Liedel	2	4	S
2182642	E	Laser in automotive engineering (p. 294)	J. Schneider	2	4	S
2162280	EM	Mathematical Methods in Structural Mechanics (p. 310)	T. Böhlke	3	5	S
2173580	E	Mechanics and Strength of Polymers (p. 312)	B. Graf von Bernstorff	2	4	W
2183702	E	Modelling of Microstructures (p. 320)	A. August, B. Nestler, D. Weygand	3	5	W
2162344	EM	Nonlinear Continuum Mechanics (p. 325)	T. Böhlke	2	5	S
2181750	EM	Multi-scale Plasticity (p. 331)	K. Schulz, C. Greiner	2	4	W
2173590	E	Polymer Engineering I (p. 334)	P. Elsner	2	4	W
2183640	E (P)	Laboratory “Laser Materials Processing” (p. 335)	J. Schneider, W. Pfleging	3	4	W/S
2126749	EM	Advanced powder metals (p. 348)	R. Oberacker	2	4	S
2182572	E	Failure Analysis (p. 355)	C. Greiner, J. Schneider	2	4	W
2173571	E	Welding Technology (p. 357)	M. Farajian	2	4	W
2173585	E	Fatigue of Metallic Materials (p. 359)	K. Lang	2	4	W
2126775	EM	Structural Ceramics (p. 375)	M. Hoffmann	2	4	S
2174579	E	Technology of steel components (p. 387)	V. Schulze	2	4	S
2181715	E	Failure of Structural Materials: Fatigue and Creep (p. 399)	P. Gruber, P. Gumbsch, O. Kraft	2	4	W
2181711	E	Failure of structural materials: deformation and fracture (p. 400)	P. Gumbsch, D. Weygand, O. Kraft	3	4	W
2174586	E	Materials Characterization (p. 406)	J. Gibmeier	3	7	W
2174574	E	Materials for Lightweight Construction (p. 407)	K. Weidenmann	2	4	S
2182740	EM	Materials modelling: dislocation based plasticity (p. 409)	D. Weygand	2	4	S
2161983	EM	Mechanics of laminated composites (p. 311)	E. Schnack	2	4	W
2193003	EM	Solid State Reactions and Kinetics of Phase Transformations (with exercises) (p. 253)	P. Franke	2	4	W

ID	Cat	Course	Lecturer	h	CP	Term
2193002	EM	Fundamentals in Materials Thermodynamics and Heterogeneous Equilibria (with exercises) (p. 392)	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 31: Mechatronics

ID	Cat	Course	Lecturer	h	CP	Term
2138340	K	Automotive Vision (eng.) (p. 249)	C. Stiller, M. Lauer	3	6	S
2105016	K	Computational Intelligence (p. 214)	R. Mikut, W. Jakob, M. Reischl	2	4	W
2106014	K	Data Analytics for Engineers (p. 215)	R. Mikut, M. Reischl, J. Stegmaier	3	5	S
2105011	K	Introduction into Mechatronics (p. 223)	M. Reischl, M. Lorch	3	6	W
2162235	K	Introduction into the multi-body dynamics (p. 224)	W. Seemann	3	5	S
2105024	K	Modern Control Concepts I (p. 321)	J. Matthes, L. Gröll	2	4	S
2105018	E	Simulation of Optical Systems (p. 367)	I. Sieber	2	4	W
2138336	K	Behaviour Generation for Vehicles (p. 398)	C. Stiller, M. Werling	2	4	S
2150904	E	Automated Manufacturing Systems (p. 200)	J. Fleischer	6	8	S
2106005	E	Automation Systems (p. 202)	M. Kaufmann	2	4	S
2114092	E	BUS-Controls (p. 207)	M. Geimer	2	4	S
2147175	E	CAE-Workshop (p. 210)	A. Albers, Assistenten	3	4	W/S
2137309	E	Digital Control (p. 217)	M. Knoop	2	4	W
23321	E	Hybrid and Electric Vehicles (p. 275)	M. Doppelbauer, M. Schiefer	3	4	W
2118183	E	IT-Fundamentals of Logistics (p. 285)	F. Thomas	2	4	S
2161224	E	Machine Dynamics (p. 301)	C. Proppe	3	5	S
2162220	E	Machine Dynamics II (p. 302)	C. Proppe	2	4	W
2181710	E	Mechanics in Microtechnology (p. 313)	P. Gruber, C. Greiner	2	4	W
2105014	E (P)	Laboratory mechatronics (p. 314)	C. Stiller, M. Lorch, W. Seemann	3	4	W
24659	E	Human-Machine-Interaction (p. 315)	M. Beigl	2	3	S
2138326	E	Measurement II (p. 316)	C. Stiller	2	4	S
2142897	E	Microenergy Technologies (p. 318)	M. Kohl	2	4	S
2141865	E	Novel actuators and sensors (p. 324)	M. Kohl, M. Sommer	2	4	W
2147161	E	Intellectual Property Rights and Strategies in Industrial Companies (p. 328)	F. Zacharias	2	4	W/S
2145182	E	Project management in Global Product Engineering Structures (p. 347)	P. Gutzmer	2	4	W
24152	E	Robotics I – Introduction to robotics (p. 354)	R. Dillmann, T. Asfour	2	6	W
23109	E	Signals and Systems (p. 364)	F. Puente, F. Puente León	2	6	W
2146192	E	Sustainable Product Engineering (p. 377)	K. Ziegahn	2	4	S
2106033	E	System Integration in Micro- and Nanotechnology (p. 378)	U. Gengenbach	2	4	S
2123375	E	Virtual Reality Laboratory (p. 404)	J. Ovtcharova	3	4	W/S
2150550	E (P)	Laboratory Production Metrology (p. 338)	B. Häfner	3	4	S
2105032	E	Micro- and nanosystem integration for medical, fluidic and optical applications (p. 319)	L. Koker, U. Gengenbach, I. Sieber	2	4	W
2162240	EM	Mathematical Foundation for Computational Mechanics (p. 306)	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 38: Production Systems

ID	Cat	Course	Lecturer	h	CP	Term
2109035	K	Human Factors Engineering I: Ergonomics (p. 187)	B. Deml	2	4	W
2109036	K	Human Factors Engineering II: Work Organisation (p. 188)	B. Deml	2	4	W
2149657	K	Manufacturing Technology (p. 251)	V. Schulze, F. Zanger	6	8	W
2150660	K	Integrated Production Planning in the Age of Industry 4.0 (p. 284)	G. Lanza	6	8	S
2117051	K	Material flow in logistic systems (p. 303)	K. Furmans	4	6	W
2149902	K	Machine Tools and Industrial Handling (p. 410)	J. Fleischer	6	8	W
2150904	E	Automated Manufacturing Systems (p. 200)	J. Fleischer	6	8	S
2149903	E	Design Project Machine Tools and Industrial Handling (p. 234)	J. Fleischer	2	4	W
2118085	E	Automotive Logistics (p. 298)	K. Furmans	2	4	S
2121350	E	Product Lifecycle Management (p. 340)	J. Ovtcharova, T. Maier	3	4	W
2149667	E	Quality Management (p. 349)	G. Lanza	2	4	W
2121001	E	Integrated Information Systems for engineers (p. 383)	J. Ovtcharova	3	4	S
2150550	E (P)	Laboratory Production Metrology (p. 338)	B. Häfner	3	4	S

Conditions: None
Recommendations:
Learning Outcomes: The students...

- are able to choose methods of production science target-oriented in familiar situations and are able to justify their selection.
- are able to describe and compare production processes exemplarily.
- are able to transfer known solutions to given problems 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 results of others at the solution of given problems.
- have the ability to present their own results in written form and are able to interpret them.
- 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 44: Technical Logistics

ID	Cat	Course	Lecturer	h	CP	Term
2117095	KP	Basics of Technical Logistics (p. 265)	M. Mittwollen, J. Oellerich	4	6	W
2118087	K	Selected Applications of Technical Logistics (p. 193)	M. Mittwollen, V. Milushev	3	4	S
2118088	K	Selected Applications of Technical Logistics - Project (p. 194)	M. Mittwollen, V. Milushev	2	2	S
2117096	K	Elements of Technical Logistics (p. 228)	M. Mittwollen, G. Fischer	3	4	W
2117097	K	Elements of Technical Logistics - Project (p. 229)	M. Mittwollen, G. Fischer	4	2	W
2150904	E	Automated Manufacturing Systems (p. 200)	J. Fleischer	6	8	S
2117500	E	Energy efficient intralogistic systems (p. 230)	M. Braun, F. Schönung	2	4	W
2118183	EM	IT-Fundamentals of Logistics (p. 285)	F. Thomas	2	4	S
2138341	E	Cogitive Automobiles - Laboratory (p. 288)	C. Stiller, M. Lauer	3	6	S
2118097	E	Warehousing and distribution systems (p. 292)	K. Furmans	2	4	S
2117051	E	Material flow in logistic systems (p. 303)	K. Furmans	4	6	W
2500005	E	Production and Logistics Controlling (p. 343)	H. Wlcek	2	3	W
2149667	E	Quality Management (p. 349)	G. Lanza	2	4	W
2117061	E	Safety Engineering (p. 363)	H. Kany	2	4	W
2138336	E	Behaviour Generation for Vehicles (p. 398)	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 50: Rail System Technology

ID	Cat	Course	Lecturer	h	CP	Term
2115919	KP	Rail System Technology (p. 203)	P. Gratzfeld	2	4	W/S
2115996	KP	Rail Vehicle Technology (p. 356)	P. Gratzfeld	2	4	W/S
2138340	E	Automotive Vision (eng.) (p. 249)	C. Stiller, M. Lauer	3	6	S
2114914	E	Railways in the Transportation Market (p. 216)	P. Gratzfeld	2	4	S
2114346	E	Electric Rail Vehicles (p. 227)	P. Gratzfeld	2	4	S
2113102	E	Vehicle Lightweight design – Strategies, Concepts, Materials (p. 246)	F. Henning	2	4	W
2114053	E	Composite Manufacturing – Polymers, Fibers, Semi-Finished Products, Manufacturing Technologies (p. 250)	F. Henning	2	4	S
2115995	E	Project Management in Rail Industry (p. 346)	P. Gratzfeld	2	4	W
2162256	E	Computational Vehicle Dynamics (p. 351)	C. Proppe	2	4	S
2115009	E	Seminar for Rail System Technology (p. 361)	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 52: Production Engineering

ID	Cat	Course	Lecturer	h	CP	Term
2118092	K	Selected Topics in Manufacturing Technologies (p. 195)	V. Schulze	2	4	W
3110041	K	Introduction to Human Factors Engineering (p. 220)	B. Deml	2	4	W
3118095	K	Global Logistics (p. 261)	K. Furmans, T. Kivelä, K. Dörr	2	4	S

Conditions:
Recommendations:
Learning Outcomes: The students acquire in the compulsory core subjects profound knowledge about the scientific theories, principles and methods of 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 module, the students are able

- to analyse and solve planning and layout problems on the level of the enterprise, production, processes and work tasks,
- to plan and control a production,
- to evaluate and configure the quality and efficiency of production, processes and products.

Remarks:

SP 57: Combustion engine techniques

ID	Cat	Course	Lecturer	h	CP	Term
2133123	KP	Fundamentals of Combustion Engine Technology (p. 380)	S. Bernhardt, H. Kubach, J. Pfeil, O. Toedter, U. Wagner, A. Velji	2	5	W
2134150	K	Analysis of Exhaust Gas und Lubricating Oil in Combustion Engines (p. 179)	M. Gohl, H. Kubach	2	4	S
2133108	K	Fuels and Lubricants for Combustion Engines (p. 205)	B. Kehrwald, H. Kubach	2	4	W
2134137	K	Engine measurement techniques (p. 323)	S. Bernhardt	2	4	S
2133132	E	Alternative Powertrain for Automobiles (p. 181)	K. Noreikat, H. Kubach	2	4	W
2133112	E	Drive Systems and Possibilities to Increase Efficiency (p. 184)	H. Kollmeier	1	2	W
2133130	E	Numerical Methods for combustion process development (p. 204)	U. Waldenmaier, H. Kubach	1	2	W
2134138	E	Fundamentals of catalytic exhaust gas aftertreatment (p. 264)	E. Lox, H. Kubach, O. Deutschmann, J. Grunwaldt	2	4	S
2134001	E/P (P)	Engine Laboratory (p. 322)	U. Wagner	2	4	S
2133125	E	Ignition systems (p. 414)	O. Toedter	2	4	W
2134153	E	Boosting of Combustion Engines (p. 192)	J. Kech	2	4	S

Conditions:
Recommendations: Recommended Courses:

- 2165512 Heat and Mass Transfer
- 2165515 Fundamentals of combustion I

Learning Outcomes: After completition of this „Schwerpunkt“ students are able to

- Describe and explain the working principal of different engine types
- Name the challenges in engine development
- Describe the correlations between engine operation, application parameters and emissions

Remarks:

ID	Cat	Course	Lecturer	h	CP	Term
2161212	K	Vibration Theory (p. 384)	A. Fidlin	3	5	W
2161224	K	Machine Dynamics (p. 301)	C. Proppe	3	5	S
2162241	K	Mathematical methods of vibration theory (p. 309)	W. Seemann	3	5	S
2163113	K	Theory of Stability (p. 370)	A. Fidlin	4	6	S
2162247	K	Introduction to Nonlinear Vibrations (p. 226)	A. Fidlin	4	7	W
2162220	E	Machine Dynamics II (p. 302)	C. Proppe	2	4	W
2161241	E (P)	Schwingungstechnisches Praktikum (p. 360)	A. Fidlin	3	4	S
2161219	E	Wave Propagation (p. 405)	W. Seemann	2	4	W
2163111	E	Dynamics of the Automotive Drive Train (p. 219)	A. Fidlin	4	5	W
2162225	E	Experimental Dynamics (p. 236)	A. Fidlin	3	5	S
2113806	E	Vehicle Comfort and Acoustics I (p. 242)	F. Gauterin	2	4	W
2114856	E	Vehicle Ride Comfort & Acoustics I (eng.) (p. 243)	F. Gauterin	2	4	S
2114825	E	Vehicle Comfort and Acoustics II (p. 244)	F. Gauterin	2	4	S
2162246	E	Computational Dynamics (p. 350)	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. 224)	W. Seemann	3	5	S
2161224	K	Machine Dynamics (p. 301)	C. Proppe	3	5	S
2161206	K	Mathematical Methods in Dynamics (p. 307)	C. Proppe	2	5	W
2163111	K	Dynamics of the Automotive Drive Train (p. 219)	A. Fidlin	4	5	W
2181740	E	Atomistic simulations and molecular dynamics (p. 189)	C. Brandl, P. Gumbsch	2	4	S
2162241	E	Mathematical methods of vibration theory (p. 309)	W. Seemann	3	5	S
2114095	E	Simulation of Coupled Systems (p. 365)	M. Geimer	4	4	S
2162225	E	Experimental Dynamics (p. 236)	A. Fidlin	3	5	S
2162246	E	Computational Dynamics (p. 350)	C. Proppe	2	4	S
2162216	E	Computerized Multibody Dynamics (p. 352)	W. Seemann	2	4	S
2162220	E	Machine Dynamics II (p. 302)	C. Proppe	2	4	W
2162256	E	Computational Vehicle Dynamics (p. 351)	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 57: Combustion engine techniques (p. 176)[SP_57_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: Agile product innovation management - value-driven planning of new products [2122300]

Coordinators: R. Kläger
Part of the modules: SP 17: Information Management (p. 165)[SP_17_mach]

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

Learning Control / Examinations
Oral examination, 20 min.

Conditions
None

Learning Outcomes
Students are able to replicate the essential correlations, procedures and structure elements for the product / innovation planning and to use it as a guideline for the planning of new products.
Students get a basic understanding about agile innovation processes and are able to describe essential prerequisites.
Students are able to demonstrate the added value of a product in consideration of a system-oriented approach. In addition, they are able to interpret unique selling points (USP).
Students are able to deduce the correlation between the added value of superior products and the creativity/innovation.
Students are able to apply methods and tools for digital product planning on specific use cases.
Students are able to explain elements and methods of computer-based ideas management and requirements modeling.
Students are able to describe the assistance for the product planning process in the development phase using RP-systems. Suitable 3D-Printing can be selected for specific use cases.

Content
Planning / innovation of new products, Agile product innovation management, Integration of product innovation planning into the business process, Elements and methods of computer-aided product planning, Rapid Prototyping, Information logistics.

Media
Lecture slides

Remarks
Participation is limited.

Course: Alternative Powertrain for Automobiles [2133132]

Coordinators: K. Noreikat, H. Kubach
Part of the modules: SP 57: Combustion engine techniques (p. 176)[SP_57_mach], SP 12: Automotive Technology (p. 160)[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: Applied Tribology in Industrial Product Development [2145181]

Coordinators: A. Albers, B. Lorentz
Part of the modules: SP 02: Powertrain Systems (p. 157)[SP_02_mach], SP 10: Engineering Design (p. 158)[SP_10_mach]

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: Drive Train of Mobile Machines [2113077]

Coordinators: M. Geimer, M. Scherer, D. Engelmann
Part of the modules: SP 02: Powertrain Systems (p. 157)[SP_02_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 57: Combustion engine techniques (p. 176)[SP_57_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. 157)[SP_02_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach], SP 10: Engineering Design (p. 158)[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 02: Powertrain Systems (p. 157)[SP_02_mach], SP 10: Engineering Design (p. 158)[SP_10_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: Human Factors Engineering I: Ergonomics [2109035]

Coordinators: B. Deml
Part of the modules: SP 38: Production Systems (p. 172)[SP_38_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 38: Production Systems (p. 172)[SP_38_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: Atomistic simulations and molecular dynamics [2181740]

Coordinators: C. Brandl, P. Gumbsch
Part of the modules: (p. 178)[SP_61_mach], SP 26: Materials Science and Engineering (p. 168)[SP_26_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 26: Materials Science and Engineering (p. 168)[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. 168)[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 57: Combustion engine techniques (p. 176)[SP_57_mach], SP 24: Energy Converting Engines (p. 167)[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. 173)[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. 173)[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 in Manufacturing Technologies [2118092]

Coordinators: V. Schulze
Part of the modules: SP 52: Production Engineering (p. 175)[SP_52_mach]

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

Learning Control / Examinations
The assessment is carried out as an oral exam.

Conditions
None

Recommendations
None

Learning Outcomes
The students ...

- are capable to specify different manufacturing processes and to differentiate against each other.
- are able to classify the manufacturing processes by their structure and functionality according to the specific main groups.
- are able to explain the characteristics, function and field of application of different manufacturing processes.
- are qualified to evaluate different processes regarding specific applications based on technical aspects.

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 process knowledge of the common processes. The lecture covers the basic principles of manufacturing technology and deals with the manufacturing processes according to their classification into main groups regarding technical and economic aspects.
The following topics will be covered:

- 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

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

Literature
Lecture Notes

Remarks
None

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

Coordinators: R. Dagan
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[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. 167)[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 and Development of Mobile Machines [2113079]

Coordinators: M. Geimer, J. Siebert
Part of the modules: SP 10: Engineering Design (p. 158)[SP_10_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. 157)[SP_02_mach], SP 12: Automotive Technology (p. 160)[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 44: Technical Logistics (p. 173)[SP_44_mach], SP 38: Production Systems (p. 172)[SP_38_mach], SP 31: Mechatronics (p. 170)[SP_31_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
8	6	Summer term	de

Learning Control / Examinations
The assessment is carried out as an oral exam.

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 31: Mechatronics (p. 170)[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. 174)[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 57: Combustion engine techniques (p. 176)[SP_57_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 57: Combustion engine techniques (p. 176)[SP_57_mach], SP 24: Energy Converting Engines (p. 167)[SP_24_mach], SP 15: Fundamentals of Energy Technology (p. 163)[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: Biomechanics: design in nature and inspired by nature [2181708]

Coordinators: C. Mattheck
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[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: BUS-Controls [2114092]

Coordinators: M. Geimer
Part of the modules: SP 31: Mechatronics (p. 170)[SP_31_mach], SP 18: Information Technology (p. 166)[SP_18_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: CATIA CAD training course [2123358]

Coordinators: J. Ovtcharova
Part of the modules: SP 17: Information Management (p. 165)[SP_17_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 CATIA and generate drawings due to the created geometry
- carry out FE-studies and kinematic simulations using the integrated CAE tools
- use advanced, knowledge-based functionalities of CATIA to automate the creation of geometry and thus to ensure the reusability of the models.

Content
The participant will learn the following knowledge:

- Basics of CATIA such as user interface, handling etc.
- Production and processing of different model types
- Production of basic geometries and parts
- Generation of detailed drawings
- Integration of partial solutions in modules
- Working with constrains
- Strength analysis with FEM
- Kinematic simulation with DMU
- Dealing with CATIA Knowledgeware

Literature
practical course skript

Remarks
For the practical course attendance is compulsory.

Course: CAD-NX training course [2123357]

Coordinators: J. Ovtcharova
Part of the modules: SP 17: Information Management (p. 165)[SP_17_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 10: Engineering Design (p. 158)[SP_10_mach], SP 17: Information Management (p. 165)[SP_17_mach], SP 13: Strength of Materials / Continuum Mechanics (p. 162)[SP_13_mach], SP 31: Mechatronics (p. 170)[SP_31_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: CFD-Lab using Open Foam [2169459]

Coordinators: R. Koch
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[SP_15_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: Computational Homogenization on Digital Image Data [2161123]

Coordinators: M. Schneider
Part of the modules: SP 13: Strength of Materials / Continuum Mechanics (p. 162)[SP_13_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 computional 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 31: Mechatronics (p. 170)[SP_31_mach], SP 18: Information Technology (p. 166)[SP_18_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 31: Mechatronics (p. 170)[SP_31_mach], SP 18: Information Technology (p. 166)[SP_18_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: Railways in the Transportation Market [2114914]

Coordinators: P. Gratzfeld
Part of the modules: SP 50: Rail System Technology (p. 174)[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: Digital Control [2137309]

Coordinators: M. Knoop
Part of the modules: SP 31: Mechatronics (p. 170)[SP_31_mach], SP 18: Information Technology (p. 166)[SP_18_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: Designing with numerical methods in product development [2161229]

Coordinators: E. Schnack
Part of the modules: SP 10: Engineering Design (p. 158)[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: Dynamics of the Automotive Drive Train [2163111]

Coordinators: A. Fidlin
Part of the modules: (p. 177)[SP_60_mach], SP 02: Powertrain Systems (p. 157)[SP_02_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach], (p. 178)[SP_61_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: Introduction to Human Factors Engineering [3110041]

Coordinators: B. Deml
Part of the modules: SP 52: Production Engineering (p. 175)[SP_52_mach]

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

Learning Control / Examinations
oral exam

Conditions
none

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

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

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

Content

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

Literature
Handout and literature online ILIAS.

Course: Introduction to the Finite Element Method [2162282]

Coordinators: T. Böhlke
Part of the modules: SP 13: Strength of Materials / Continuum Mechanics (p. 162)[SP_13_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. 163)[SP_15_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 into Mechatronics [2105011]

Coordinators: M. Reischl, M. Lorch
Part of the modules: SP 31: Mechatronics (p. 170)[SP_31_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: (p. 178)[SP_61_mach], SP 31: Mechatronics (p. 170)[SP_31_mach], SP 02: Powertrain Systems (p. 157)[SP_02_mach]

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

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

Conditions
None.

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

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

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

Course: Introduction to numerical fluid dynamics [2157444]

Coordinators: B. Pritz
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[SP_15_mach], SP 24: Energy Converting Engines (p. 167)[SP_24_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: (p. 177)[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. 174)[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 44: Technical Logistics (p. 173)[SP_44_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 44: Technical Logistics (p. 173)[SP_44_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 efficient intralogistic systems [2117500]

Coordinators: M. Braun, F. Schönung
Part of the modules: SP 44: Technical Logistics (p. 173)[SP_44_mach], SP 02: Powertrain Systems (p. 157)[SP_02_mach], SP 15: Fundamentals of Energy Technology (p. 163)[SP_15_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. 163)[SP_15_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 15: Fundamentals of Energy Technology (p. 163)[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: Design Project Machine Tools and Industrial Handling [2149903]

Coordinators: J. Fleischer
Part of the modules: SP 38: Production Systems (p. 172)[SP_38_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 26: Materials Science and Engineering (p. 168)[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: Experimental Dynamics [2162225]

Coordinators: A. Fidlin
Part of the modules: (p. 177)[SP_60_mach], (p. 178)[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. 167)[SP_24_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. 168)[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: Handling Characteristics of Motor Vehicles I [2113807]

Coordinators: H. Unrau
Part of the modules: SP 12: Automotive Technology (p. 160)[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 12: Automotive Technology (p. 160)[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. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[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: (p. 177)[SP_60_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture '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: (p. 177)[SP_60_mach], SP 12: Automotive Technology (p. 160)[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 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: (p. 177)[SP_60_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach]

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

Learning Control / Examinations
Oral Examination

Duration: 30 up to 40 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture '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 12: Automotive Technology (p. 160)[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 50: Rail System Technology (p. 174)[SP_50_mach], SP 12: Automotive Technology (p. 160)[SP_12_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 12: Automotive Technology (p. 160)[SP_12_mach]

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

Learning Control / Examinations
Written examination

Duration: 90 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students have an overview of the system science field of mechatronics and its application in the area of vehicle conception, especially in the context of vehicle system dynamics. They know the tools and methods for a 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. 160)[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 50: Rail System Technology (p. 174)[SP_50_mach], SP 18: Information Technology (p. 166)[SP_18_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach], SP 31: Mechatronics (p. 170)[SP_31_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 50: Rail System Technology (p. 174)[SP_50_mach], SP 12: Automotive Technology (p. 160)[SP_12_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: Manufacturing Technology [2149657]

Coordinators: V. Schulze, F. Zanger
Part of the modules: SP 10: Engineering Design (p. 158)[SP_10_mach], SP 38: Production Systems (p. 172)[SP_38_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. 168)[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: Fluid Technology [2114093]

Coordinators: M. Geimer, M. Scherer, L. Brinkschulte
Part of the modules: SP 24: Energy Converting Engines (p. 167)[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: Gasdynamics [2154200]

Coordinators: F. Magagnato
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[SP_15_mach], SP 24: Energy Converting Engines (p. 167)[SP_24_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: Foundry Technology [2174575]

Coordinators: C. Wilhelm
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[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 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: Fundamentals of Energy Technology [2130927]

Coordinators: A. Badea, X. Cheng
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[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. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach]

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

Learning Control / Examinations
Written examination

Duration: 120 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture '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 10: Engineering Design (p. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach]

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

Learning Control / Examinations
Written examination

Duration: 120 minutes

Auxiliary means: none

Conditions
Examination in English
Can not be combined with lecture '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 12: Automotive Technology (p. 160)[SP_12_mach]

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

Learning Control / Examinations
Written Examination

Duration: 90 minutes

Auxiliary means: none

Conditions
Can not be combined with lecture '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: Global Logistics [3118095]

Coordinators: K. Furmans, T. Kivelä, K. Dörr
Part of the modules: SP 52: Production Engineering (p. 175)[SP_52_mach]

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

Learning Control / Examinations
oral examination, 20 minutes

Conditions
Attendance during lectures is required

Recommendations
none

Learning Outcomes
Students are able to:

- describe material flow processes qualitativ and quantitativ,
- plan material flow systems, illustrate them in simple models and analyse them regarding their performance,
- use methods to determine performance indicators like throughput, utilization, etc.,
- describe logistical tasks,
- design logistical systems suitable to the respective task,
- determine essential influencing parameters on the bullwhip effect and
- use optimizing solution methods.

Content
Conveyor Systems

- Basic elements of conveyor systems
- Key figures
- Branching elements
  - continuous/partially-continuous
  - deterministic/stochastic switch
- Integration elements
  - continuous/partially-continuous
  - dispatching rules

Queueing Theory and Production Logistics

- Basic queueing systems
- Distributions
- M|M|1 and M|G|1 model

Application on production logistics, Distribution Centers and Order Picking

- The location problem
- Distribution centers

- Inventory management
- Order picking

Vehicle Routing and Types of vehicle routing problems

- Linear programming model and graph theoretic model
- Heuristics
- Supporting technologies

Optimization of Logistical Networks

- Objectives
- Cooperative strategies
- Supply chain management
- Implementation

Media
presentations, blackboard, book

Literature
Literature: Arnold, Dieter; Furmans, Kai : Materialfluss in Logistiksystemen; Springer-Verlag Berlin Heidelberg, 2009

Remarks
The course takes place in form of a block event, i.e. all lectures will be given in one week. The dates of the lecture, i.e. the respective week, will be published on the IFL homepage.

Course: Basic principles of powder metallurgical and ceramic processing [2193010]

Coordinators: G. Schell, R. Oberacker
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[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 57: Combustion engine techniques (p. 176)[SP_57_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach], SP 24: Energy Converting Engines (p. 167)[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: Basics of Technical Logistics [2117095]

Coordinators: M. Mittwollen, J. Oellerich
Part of the modules: SP 44: Technical Logistics (p. 173)[SP_44_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. 167)[SP_24_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 15: Fundamentals of Energy Technology (p. 163)[SP_15_mach], SP 24: Energy Converting Engines (p. 167)[SP_24_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: Fundamentals for Design of Motor-Vehicles Bodies I [2113814]

Coordinators: H. Bardehle
Part of the modules: SP 10: Engineering Design (p. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[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. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[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. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Winter term	de

Learning Control / Examinations
Oral group examination

Duration: 30 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students have proper knowledge about the process of commercial vehicle development starting from the concept and the underlying original idea to the real design. They know that the customer requirements, the technical realisability, the functionality and the economy are important drivers.
The students are able to develop parts and components. Furthermore they have knowledge about different cab concepts, the interior and the interior design process. Consequently they are ready to analyze and to judge concepts of commercial vehicles as well as to participate competently in the commercial vehicle development.

Content
1. Introduction, definitions, history
2. Development tools
3. Complete vehicle
4. Cab, bodyshell work
5. Cab, interior fitting
6. Alternative drive systems
7. Drive train
8. Drive system diesel engine
9. Intercooled diesel engines

Literature
1. Marwitz, H., Zittel, S.: ACTROS – die neue schwere Lastwagenbaureihe von Mercedes-Benz, ATZ 98, 1996, Nr. 9

2. Alber, P., McKellip, S.: ACTROS – Optimierte passive Sicherheit, ATZ 98, 1996

3. Morschheuser, K.: Airbag im Rahmenfahrzeug, ATZ 97, 1995, S. 450 ff.

Course: Fundamentals in the Development of Commercial Vehicles II [2114844]

Coordinators: J. Zürn
Part of the modules: SP 10: Engineering Design (p. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach]

ECTS Credits	Hours per week	Term	Instruction language
2	1	Summer term	de

Learning Control / Examinations
Oral group examination

Duration: 30 minutes

Auxiliary means: none

Conditions
None.

Recommendations
None.

Learning Outcomes
The students know the advantages and disadvantages of different drives. Furthermore they are familiar with components, such as transfer box, propeller shaft, powered and non-powered frontaxle etc. Beside other mechanical components, such as chassis, axle suspension and braking system, also electric and electronic systems are known. Consequently the student are able to analyze and to judge the general concepts as well as to adjust them precisely with the area of application.

Content
1. Gear boxes of commercial vehicles
2. Intermediate elements of the drive train
3. Axle systems
4. Front axles and driving dynamics
5. Chassis and axle suspension
6. Braking System
7. Systems
8. Excursion

Literature
1. Schittler, M., Heinrich, R., Kerschbaum, W.: Mercedes-Benz Baureihe 500 – neue V-Motorengeneration für schwere Nutzfahrzeuge, MTZ 57 Nr. 9, S. 460 ff., 1996

2. Robert Bosch GmbH (Hrsg.): Bremsanlagen für Kraftfahrzeuge, VDI-Verlag, Düsseldorf, 1. Auflage, 1994

3. Rubi, V., 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. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[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. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[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: Advanced Methods in Strength of Materials [2161252]

Coordinators: T. Böhlke
Part of the modules: SP 13: Strength of Materials / Continuum Mechanics (p. 162)[SP_13_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: Hybrid and Electric Vehicles [23321]

Coordinators: M. Doppelbauer, M. Schiefer
Part of the modules: SP 02: Powertrain Systems (p. 157)[SP_02_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach], SP 31: Mechatronics (p. 170)[SP_31_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. 163)[SP_15_mach], SP 24: Energy Converting Engines (p. 167)[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: Industrial aerodynamics [2153425]

Coordinators: T. Breitling, B. Frohnapfel
Part of the modules: SP 12: Automotive Technology (p. 160)[SP_12_mach]

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

Learning Control / Examinations
oral

Duration: 30 minutes

no auxiliary means

Conditions
None.

Learning Outcomes
Students can describe the different challenges of 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: Information Engineering [2122014]

Coordinators: J. Ovtcharova
Part of the modules: SP 17: Information Management (p. 165)[SP_17_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 17: Information Management (p. 165)[SP_17_mach], SP 18: Information Technology (p. 166)[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 18: Information Technology (p. 166)[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. 166)[SP_18_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: Integrative Strategies in Production and Development of High Performance Cars [2150601]

Coordinators: K. Schlichtenmayer
Part of the modules: SP 10: Engineering Design (p. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach]

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

Learning Control / Examinations
The assessment is carried out as 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 Production Planning in the Age of Industry 4.0 [2150660]

Coordinators: G. Lanza
Part of the modules: SP 38: Production Systems (p. 172)[SP_38_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: IT-Fundamentals of Logistics [2118183]

Coordinators: F. Thomas
Part of the modules: SP 44: Technical Logistics (p. 173)[SP_44_mach], SP 18: Information Technology (p. 166)[SP_18_mach], SP 17: Information Management (p. 165)[SP_17_mach], SP 31: Mechatronics (p. 170)[SP_31_mach], SP 02: Powertrain Systems (p. 157)[SP_02_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: I4.0 Systems platform [2123900]

Coordinators: J. Ovtcharova, T. Maier
Part of the modules: SP 17: Information Management (p. 165)[SP_17_mach]

ECTS Credits	Hours per week	Term	Instruction language
6	4	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

- Students are able to describe the fundamental concepts, challenges, and objectives of Industrie 4.0. The essential terms in context of information management can be named and explained.
- Students can explain the necessary information flow between the different IT systems. They get practically knowledge about using current IT systems in context of I4.0, from order to production.
- 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 continuous information flow and discuss and provide proposals for solutions
- Student teams can also provide prototypically implementation of the obtained solutions using given IT systems and present the final results.

Content
Industry 4.0, IT systems for fabrication (e.g.: CAx, PDM, CAM, ERP, MES), 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: Introduction to Ceramics [2125757]

Coordinators: M. Hoffmann
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[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: Cogitive Automobiles - Laboratory [2138341]

Coordinators: C. Stiller, M. Lauer
Part of the modules: SP 44: Technical Logistics (p. 173)[SP_44_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: Design with Plastics [2174571]

Coordinators: M. Liedel
Part of the modules: SP 10: Engineering Design (p. 158)[SP_10_mach], SP 26: Materials Science and Engineering (p. 168)[SP_26_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 10: Engineering Design (p. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[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: Motor Vehicle Laboratory [2115808]

Coordinators: M. Frey
Part of the modules: SP 12: Automotive Technology (p. 160)[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: Warehousing and distribution systems [2118097]

Coordinators: K. Furmans
Part of the modules: SP 44: Technical Logistics (p. 173)[SP_44_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 12: Automotive Technology (p. 160)[SP_12_mach], SP 26: Materials Science and Engineering (p. 168)[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 02: Powertrain Systems (p. 157)[SP_02_mach], SP 10: Engineering Design (p. 158)[SP_10_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. 163)[SP_15_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: Automotive Logistics [2118085]

Coordinators: K. Furmans
Part of the modules: SP 38: Production Systems (p. 172)[SP_38_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: Machine Vision [2137308]

Coordinators: C. Stiller, M. Lauer
Part of the modules: SP 18: Information Technology (p. 166)[SP_18_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: Leadership and Conflict Management (in German) [2110017]

Coordinators: H. Hatzl
Part of the modules: SP 10: Engineering Design (p. 158)[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: (p. 178)[SP_61_mach], (p. 177)[SP_60_mach], SP 31: Mechatronics (p. 170)[SP_31_mach], SP 02: Powertrain Systems (p. 157)[SP_02_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: (p. 178)[SP_61_mach], (p. 177)[SP_60_mach], SP 31: Mechatronics (p. 170)[SP_31_mach], SP 02: Powertrain Systems (p. 157)[SP_02_mach]

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

Learning Control / Examinations
oral exam, no auxiliary means allowed

Conditions
none

Recommendations
Machine Dynamics

Learning Outcomes
Students are able to develop and analyze detailed models in machine dynamics that encompass continuum models, fluid structure interaction, and stability analyses.

Content
• hydrodynamic bearings
• rotating shafts in hydrodynamic bearings
• belt drives
• 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. 173)[SP_44_mach], SP 38: Production Systems (p. 172)[SP_38_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 12: Automotive Technology (p. 160)[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 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. 170)[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: (p. 178)[SP_61_mach], SP 13: Strength of Materials / Continuum Mechanics (p. 162)[SP_13_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 13: Strength of Materials / Continuum Mechanics (p. 162)[SP_13_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. 177)[SP_60_mach], (p. 178)[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 Structural Mechanics [2162280]

Coordinators: T. Böhlke
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[SP_26_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: Mechanics of laminated composites [2161983]

Coordinators: E. Schnack
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[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. 168)[SP_26_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 31: Mechatronics (p. 170)[SP_31_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 10: Engineering Design (p. 158)[SP_10_mach], SP 31: Mechatronics (p. 170)[SP_31_mach], SP 18: Information Technology (p. 166)[SP_18_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 31: Mechatronics (p. 170)[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 II [2138326]

Coordinators: C. Stiller
Part of the modules: SP 31: Mechatronics (p. 170)[SP_31_mach], SP 18: Information Technology (p. 166)[SP_18_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 15: Fundamentals of Energy Technology (p. 163)[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 15: Fundamentals of Energy Technology (p. 163)[SP_15_mach], SP 31: Mechatronics (p. 170)[SP_31_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- and nanosystem integration for medical, fluidic and optical applications [2105032]

Coordinators: L. Koker, U. Gengenbach, I. Sieber
Part of the modules: SP 31: Mechatronics (p. 170)[SP_31_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: Modelling of Microstructures [2183702]

Coordinators: A. August, B. Nestler, D. Weygand
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[SP_26_mach]

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

Learning Control / Examinations
We regularly hand out exercise sheets. The individual solutions will be corrected.
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: Modern Control Concepts I [2105024]

Coordinators: J. Matthes, L. Gröll
Part of the modules: SP 31: Mechatronics (p. 170)[SP_31_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: Engine Laboratory [2134001]

Coordinators: U. Wagner
Part of the modules: SP 57: Combustion engine techniques (p. 176)[SP_57_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 57: Combustion engine techniques (p. 176)[SP_57_mach], SP 18: Information Technology (p. 166)[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: Novel actuators and sensors [2141865]

Coordinators: M. Kohl, M. Sommer
Part of the modules: SP 02: Powertrain Systems (p. 157)[SP_02_mach], SP 31: Mechatronics (p. 170)[SP_31_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: Nonlinear Continuum Mechanics [2162344]

Coordinators: T. Böhlke
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[SP_26_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: Numerical simulation of reacting two phase flows [2169458]

Coordinators: R. Koch
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[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 Fluid Mechanics [2153441]

Coordinators: F. Magagnato
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[SP_15_mach], SP 24: Energy Converting Engines (p. 167)[SP_24_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: Intellectual Property Rights and Strategies in Industrial Companies [2147161]

Coordinators: F. Zacharias
Part of the modules: SP 02: Powertrain Systems (p. 157)[SP_02_mach], SP 17: Information Management (p. 165)[SP_17_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach], SP 31: Mechatronics (p. 170)[SP_31_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. 163)[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, Photovototlaik, (Vieweg, Wiebaden, 2010)
Tom Markvart, Luis Castaner, Photovoltaics Fundamentals and Applications, (Elsevier, Oxford, 2003)
Heinrich Häberlin, Photovoltaik, (AZ Verlag, Aarau, 2007)

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. 163)[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: Multi-scale Plasticity [2181750]

Coordinators: K. Schulz, C. Greiner
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[SP_26_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 17: Information Management (p. 165)[SP_17_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-CAD Workshop [2121357]

Coordinators: J. Ovtcharova
Part of the modules: SP 17: Information Management (p. 165)[SP_17_mach]

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

Learning Control / Examinations
Assessment of another type (graded), procedure see webpage.

Conditions
None.

Learning Outcomes

Content

Course: Polymer Engineering I [2173590]

Coordinators: P. Elsner
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[SP_26_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: Laboratory “Laser Materials Processing” [2183640]

Coordinators: J. Schneider, W. Pfleging
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[SP_26_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. 166)[SP_18_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: Workshop on computer-based flow measurement techniques [2171488]

Coordinators: H. Bauer
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[SP_15_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: Laboratory Production Metrology [2150550]

Coordinators: B. Häfner
Part of the modules: SP 31: Mechatronics (p. 170)[SP_31_mach], SP 38: Production Systems (p. 172)[SP_38_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: Principles of Whole Vehicle Engineering II [2114860]

Coordinators: R. Frech
Part of the modules: SP 10: Engineering Design (p. 158)[SP_10_mach], SP 12: Automotive Technology (p. 160)[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 38: Production Systems (p. 172)[SP_38_mach], SP 17: Information Management (p. 165)[SP_17_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. 160)[SP_12_mach], SP 17: Information Management (p. 165)[SP_17_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. 173)[SP_44_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: Project Workshop: Automotive Engineering [2115817]

Coordinators: F. Gauterin, M. Gießler, M. Frey
Part of the modules: SP 12: Automotive Technology (p. 160)[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: Development of Oil-Hydraulic Powertrain Systems [2113072]

Coordinators: G. Geerling, S. Becker
Part of the modules: SP 02: Powertrain Systems (p. 157)[SP_02_mach], SP 10: Engineering Design (p. 158)[SP_10_mach], SP 24: Energy Converting Engines (p. 167)[SP_24_mach], SP 12: Automotive Technology (p. 160)[SP_12_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. 174)[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 17: Information Management (p. 165)[SP_17_mach], SP 02: Powertrain Systems (p. 157)[SP_02_mach], SP 10: Engineering Design (p. 158)[SP_10_mach], SP 31: Mechatronics (p. 170)[SP_31_mach], SP 12: Automotive Technology (p. 160)[SP_12_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: Advanced powder metals [2126749]

Coordinators: R. Oberacker
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[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 44: Technical Logistics (p. 173)[SP_44_mach], SP 38: Production Systems (p. 172)[SP_38_mach], SP 10: Engineering Design (p. 158)[SP_10_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: Computational Dynamics [2162246]

Coordinators: C. Proppe
Part of the modules: (p. 178)[SP_61_mach], (p. 177)[SP_60_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: (p. 178)[SP_61_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach], SP 50: Rail System Technology (p. 174)[SP_50_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: (p. 178)[SP_61_mach], SP 13: Strength of Materials / Continuum Mechanics (p. 162)[SP_13_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: Reliability Engineering 1 [2169550]

Coordinators: A. Konnov
Part of the modules: SP 24: Energy Converting Engines (p. 167)[SP_24_mach], SP 18: Information Technology (p. 166)[SP_18_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: Robotics I – Introduction to robotics [24152]

Coordinators: R. Dillmann, T. Asfour
Part of the modules: SP 31: Mechatronics (p. 170)[SP_31_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: Failure Analysis [2182572]

Coordinators: C. Greiner, J. Schneider
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[SP_26_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. 174)[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. 168)[SP_26_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 26: Materials Science and Engineering (p. 168)[SP_26_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. 177)[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 for Rail System Technology [2115009]

Coordinators: P. Gratzfeld
Part of the modules: SP 50: Rail System Technology (p. 174)[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. 160)[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 44: Technical Logistics (p. 173)[SP_44_mach], SP 10: Engineering Design (p. 158)[SP_10_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 31: Mechatronics (p. 170)[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 Coupled Systems [2114095]

Coordinators: M. Geimer
Part of the modules: (p. 178)[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. 160)[SP_12_mach]

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

Learning Control / Examinations
Not graded:
term paper in group work

- written part: 10 pages per person
- presentation: 15 minutes per group

Conditions
Compulsory preconditions: none

Recommendations
None.

Learning Outcomes
The students learn the connections between simulation methods, the necessary IT technique and the integration of such methods within the product development process. They know the basic approximation methods in mechanics and methods of modelling material behaviour using the finite-element-method. The students learn the integration within the product development process as well as the necessity of coupling different methods and systems. They master the modelling of heterogeneous technical systems and know the foundations of virtual reality.

Content

- approximation methods of mechanics: FDM, BEM, FEM, MBS
- material modelling using the finite-element-methode
- product life cycle
- coupling of methods and system integration
- modelling heterogeneous technical systems
- functional Digital Mock-Up (DMU), virtual prototypes

Literature
sildes of lectures will be available

Course: Simulation of Optical Systems [2105018]

Coordinators: I. Sieber
Part of the modules: SP 31: Mechatronics (p. 170)[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: Solar Thermal Energy Systems [2189400]

Coordinators: R. Dagan
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[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: (p. 177)[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 02: Powertrain Systems (p. 157)[SP_02_mach], SP 18: Information Technology (p. 166)[SP_18_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: Strategic product development - identification of potentials of innovative products [2146198]

Coordinators: A. Siebe
Part of the modules: SP 02: Powertrain Systems (p. 157)[SP_02_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach], SP 10: Engineering Design (p. 158)[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 and Heat Transfer in Energy Technology [2189910]

Coordinators: X. Cheng
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[SP_15_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: Structural Ceramics [2126775]

Coordinators: M. Hoffmann
Part of the modules: SP 26: Materials Science and Engineering (p. 168)[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: Supply chain management [2117062]

Coordinators: K. Alicke
Part of the modules: SP 17: Information Management (p. 165)[SP_17_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. 157)[SP_02_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach], SP 31: Mechatronics (p. 170)[SP_31_mach], SP 15: Fundamentals of Energy Technology (p. 163)[SP_15_mach], SP 10: Engineering Design (p. 158)[SP_10_mach], SP 17: Information Management (p. 165)[SP_17_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 31: Mechatronics (p. 170)[SP_31_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 15: Fundamentals of Energy Technology (p. 163)[SP_15_mach], SP 24: Energy Converting Engines (p. 167)[SP_24_mach], SP 10: Engineering Design (p. 158)[SP_10_mach]

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

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

Conditions
none

Recommendations
none

Learning Outcomes
Students get to know the basics of technical acoustics in general. Application of the knowledge in different fields of engineering.
Students learn physical basics of acoustics and human perception. Physical-empirical laws for determination of sound and noise levels of various emission and immission situations will be worked out or derived. Furtheron general sound measurement methods of machinery will be taught.
Students are able to understand mechanisms of sound origin, propagation and reduction, as well as measuring technics

Content
Basics of acoustics
Perception and weighting of noise (human hearing)
Description of acoustic parameters, level notation
Noise propagation
Acoustical measurement techniques

Literature
1. Lecture notes (downloadable from institute's homepage).
2. Heckl, M.; Müller, H. A.: Taschenbuch der Technischen Akustik, Springer-Verlag.
3. Veit, Ivar: Technische Akustik. Vogel-Verlag (Kamprath-Reihe), Würzburg.
4. Henn, H. et al.: Ingenieurakustik. Vieweg-Verlag.

Course: Fundamentals of Combustion Engine Technology [2133123]

Coordinators: S. Bernhardt, H. Kubach, J. Pfeil, O. Toedter, U. Wagner, A. Velji
Part of the modules: SP 57: Combustion engine techniques (p. 176)[SP_57_mach]

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: SP 18: Information Technology (p. 166)[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: Integrated Information Systems for engineers [2121001]

Coordinators: J. Ovtcharova
Part of the modules: SP 38: Production Systems (p. 172)[SP_38_mach], SP 17: Information Management (p. 165)[SP_17_mach]

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: (p. 177)[SP_60_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 10: Engineering Design (p. 158)[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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2017
Hartmut Seeger
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 26: Materials Science and Engineering (p. 168)[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: Thermal Solar Energy [2169472]

Coordinators: R. Stieglitz
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[SP_15_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. 163)[SP_15_mach], SP 24: Energy Converting Engines (p. 167)[SP_24_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 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. 167)[SP_24_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. 168)[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: Tribology [2181114]

Coordinators: M. Dienwiebel
Part of the modules: SP 02: Powertrain Systems (p. 157)[SP_02_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. 167)[SP_24_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. 167)[SP_24_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: Combustion Engines I [2133113]

Coordinators: H. Kubach, T. Koch
Part of the modules: SP 15: Fundamentals of Energy Technology (p. 163)[SP_15_mach], SP 02: Powertrain Systems (p. 157)[SP_02_mach], SP 24: Energy Converting Engines (p. 167)[SP_24_mach], SP 12: Automotive Technology (p. 160)[SP_12_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: Behaviour Generation for Vehicles [2138336]

Coordinators: C. Stiller, M. Werling
Part of the modules: SP 44: Technical Logistics (p. 173)[SP_44_mach], SP 18: Information Technology (p. 166)[SP_18_mach], SP 12: Automotive Technology (p. 160)[SP_12_mach], SP 31: Mechatronics (p. 170)[SP_31_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 26: Materials Science and Engineering (p. 168)[SP_26_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. 157)[SP_02_mach], SP 13: Strength of Materials / Continuum Mechanics (p. 162)[SP_13_mach], SP 26: Materials Science and Engineering (p. 168)[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 12: Automotive Technology (p. 160)[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 Reality Laboratory [2123375]

Coordinators: J. Ovtcharova
Part of the modules: SP 31: Mechatronics (p. 170)[SP_31_mach], SP 17: Information Management (p. 165)[SP_17_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: Wave Propagation [2161219]

Coordinators: W. Seemann
Part of the modules: (p. 177)[SP_60_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. 168)[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 26: Materials Science and Engineering (p. 168)[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. 168)[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 26: Materials Science and Engineering (p. 168)[SP_26_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. 158)[SP_10_mach], SP 38: Production Systems (p. 172)[SP_38_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 15: Fundamentals of Energy Technology (p. 163)[SP_15_mach], SP 24: Energy Converting Engines (p. 167)[SP_24_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. 167)[SP_24_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: Ignition systems [2133125]

Coordinators: O. Toedter
Part of the modules: SP 57: Combustion engine techniques (p. 176)[SP_57_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

Karlsruher Institut für Technologie

Universität des Landes Baden-Württemberg und
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Amtliche Bekanntmachung

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Studien- und Prüfungsordnung des Karlsruher Instituts für Technologie (KIT) für den Bachelorstudiengang 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 Bachelorstudiengang 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 Bachelorprüfungsordnung regelt Studienablauf, Prüfungen und den Abschluss des Studiums im Bachelorstudiengang Maschinenbau am KIT.

§ 2 Ziel des Studiums, Akademischer Grad

(1) Im Bachelorstudium sollen die wissenschaftlichen Grundlagen und die Methodenkompetenz der Fachwissenschaften vermittelt werden. Ziel des Studiums ist die Fähigkeit, einen konsekutiven Masterstudiengang erfolgreich absolvieren zu können sowie das erworbene Wissen berufsfeldbezogen anwenden zu können.

(2) Aufgrund der bestandenen Bachelorprüfung wird der akademische Grad „Bachelor of Science (B.Sc.)“ für den Bachelorstudiengang Maschinenbau verliehen.

§ 3 Regelstudienzeit, Studienaufbau, Leistungspunkte

(1) Der Studiengang nimmt teil am Programm „Studienmodelle individueller Geschwindigkeit“. Die Studierenden haben im Rahmen der dortigen Kapazitäten und Regelungen bis einschließlich drittem Fachsemester Zugang zu den Veranstaltungen des MINT-Kollegs Baden-Württemberg (im folgenden MINT-Kolleg).

(2) Die Regelstudienzeit beträgt sechs Semester. Bei einer qualifizierten Teilnahme am MINT-Kolleg bleiben bei der Anrechnung auf die Regelstudienzeit bis zu zwei Semester unberücksichtigt. Die konkrete Anzahl der Semester richtet sich nach § 8 Absatz 2 Satz 3 bis 5.

Eine qualifizierte Teilnahme liegt vor, wenn die Studierende Veranstaltungen des MINT- Kollegs für die Dauer von mindestens einem Semester im Umfang von mindestens zwei Fachkursen (Gesamtworkload 10 Semesterwochenstunden) belegt hat. Das MINT-Kolleg stellt hierüber eine Bescheinigung aus.

(3) 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 § 20 festgelegt. Näheres beschreibt das Modulhandbuch.

(4) 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.

(5) Der Umfang der für den erfolgreichen Abschluss des Studiums erforderlichen Studien- und Prüfungsleistungen wird in Leistungspunkten gemessen und beträgt insgesamt 180 Leistungspunkte.

(6) Lehrveranstaltungen können nach vorheriger Ankündigung auch in englischer Sprache angeboten werden, sofern es deutschsprachige Wahlmöglichkeiten gibt.

§ 4 Modulprüfungen, Studien- und Prüfungsleistungen

(1) Die Bachelorprüfung 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 Bachelorprüfung 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 Bachelorarbeit 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 Bachelorstudiengang 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 Bachelorstudiengang 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 abzulehnen, wenn die in Absatz 3 und 4 genannten Voraussetzungen nicht erfüllt sind.

§ 6 Durchführung von Erfolgskontrollen

(1) Erfolgskontrollen werden studienbegleitend, in der Regel im Verlauf der Vermittlung der Lehrinhalte der einzelnen Module oder zeitnah danach, durchgeführt.

(2) Die Art der Erfolgskontrolle (§ 4 Abs. 2 Nr. 1 bis 3, 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. 5 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 einer solchen 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/zur 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 der 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 und fachliche Betreuung zu gewährleisten. 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 Bachelorprüfung, 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 Orientierungsprüfungen, Verlust des Prüfungsanspruchs

(1) Die Teilmodulprüfungen Höhere Mathematik I, Technische Mechanik I, Technische Mechanik II in den Modulen Höhere Mathematik und Technische Mechanik sind bis zum Ende des Prüfungszeitraums des zweiten Fachsemesters abzulegen (Orientierungsprüfungen).

(2) Wer die Orientierungsprüfungen einschließlich etwaiger Wiederholungen bis zum Ende des Prüfungszeitraums des dritten Fachsemesters nicht erfolgreich abgelegt hat, verliert den Prüfungsanspruch im Studiengang, es sei denn, dass die Fristüberschreitung nicht selbst zu vertreten ist; hierüber entscheidet der Prüfungsausschuss auf Antrag der oder des Studierenden. Eine zweite Wiederholung der Orientierungsprüfungen ist ausgeschlossen.

Die Fristüberschreitung hat die/der Studierende insbesondere dann nicht zu vertreten, wenn eine qualifizierte Teilnahme am MINT-Kolleg im Sinne von § 3 Abs. 2 vorliegt. Ohne ausdrückliche Genehmigung des Vorsitzenden des Prüfungsausschusses gilt eine Fristüberschreitung von

1. einem Semester als genehmigt, wenn die/der Studierende eine qualifizierte Teilnahme am MINT-Kolleg gemäß § 3 Abs. 2 im Umfang von einem Semester nachweist oder
2. zwei Semestern als genehmigt, wenn die/der Studierende eine qualifizierte Teilnahme am MINT-Kolleg gemäß § 3 Abs. 2 im Umfang von zwei Semestern nachweist.

Als Nachweis gilt die vom MINT-Kolleg gemäß § 3 Abs. 2 auszustellende Bescheinigung, die beim Studierendenservice des KIT einzureichen ist. Im Falle von Nr. 1 kann der Vorsitzende des Prüfungsausschusses auf Antrag der Studierenden die Frist um ein weiteres Semester verlängern, wenn dies aus studienorganisatorischen Gründen für das fristgerechte Ablegen der Orientierungsprüfung erforderlich ist, insbesondere weil die Module, die Bestandteil der Orientierungsprüfung sind, nur einmal jährlich angeboten werden.

(3) Ist die Bachelorprüfung bis zum Ende des Prüfungszeitraums des neunten 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 in Satz 1 genannten Studienhöchstdauer zu stellen. *Absatz 2 Satz 3 bis 5 gelten entsprechend.*

(4) Der Prüfungsanspruch geht auch verloren, wenn eine nach dieser Studien- und Prüfungsordnung erforderliche Studien- oder Prüfungsleistung endgültig nicht bestanden ist oder eine Wiederholungsprüfung nach § 9 Abs. 6 nicht rechtzeitig erbracht wurde, es sei denn die Fristüberschreitung ist nicht selbst zu vertreten.

§ 9 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 Bachelorarbeit kann bei einer Bewertung mit „nicht ausreichend“ (5,0) einmal wiederholt werden. Eine zweite Wiederholung der Bachelorarbeit ist ausgeschlossen.

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§ 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 Bachelorarbeit 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 Bachelorarbeit 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 Studierender 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 § 20 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 Bachelorarbeit

(1) Voraussetzung für die Zulassung zum Modul Bachelorarbeit ist, dass die/der Studierende Modulprüfungen im Umfang von 120 LP erfolgreich abgelegt hat. Über Ausnahmen entscheidet der Prüfungsausschuss auf Antrag der/des Studierenden.

(1 a) Dem Modul Bachelorarbeit sind 15 LP zugeordnet. Es besteht aus der Bachelorarbeit und einer Präsentation. Die Präsentation hat spätestens sechs Wochen nach Abgabe der Bachelorarbeit zu erfolgen.

(2) Die Bachelorarbeit 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 § 18 Abs. 2 und 3 zur Vergabe des Themas berechtigen. Den Studierenden ist Gelegenheit zu geben, für das Thema Vorschläge zu machen. Soll die Bachelorarbeit außerhalb der KIT-Fakultät für Maschinenbau angefertigt werden, so bedarf dies der Genehmigung durch den Prüfungsausschuss. Die Bachelorarbeit 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 Bachelorarbeit erhält. Die Ausgabe des Themas erfolgt in diesem Fall über die/den Vorsitzende/n des Prüfungsausschusses.

(3) Thema, Aufgabenstellung und Umfang der Bachelorarbeit sind von dem Betreuer bzw. der Betreuerin so zu begrenzen, dass sie mit dem in Absatz 4 festgelegten Arbeitsaufwand bearbeitet werden kann.

(4) Die Bachelorarbeit 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 Bachelorarbeit entspricht 12 Leistungspunkten. Die maximale Bearbeitungsdauer beträgt drei Monate. Thema und Aufgabenstellung sind an den vorgesehenen Umfang anzupassen. Der Prüfungsausschuss legt fest, in welchen Sprachen die Bachelorarbeit geschrieben werden kann. Auf Antrag des Studierenden kann der/die Prüfende genehmigen, dass die Bachelorarbeit in einer anderen Sprache als Deutsch geschrieben wird.

(5) Bei der Abgabe der Bachelorarbeit 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 Bachelorarbeit mit „nicht ausreichend" (5,0) bewertet.

(6) Der Zeitpunkt der Ausgabe des Themas der Bachelorarbeit ist durch die Betreuerin/den Betreuer und die/den Studierenden festzuhalten und dies beim Prüfungsausschuss aktenkundig zu machen. Der Zeitpunkt der Abgabe der Bachelorarbeit 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 3 festgelegte Bearbeitungszeit auf Antrag der oder des Studierenden um höchstens einen Monat verlängern. Wird die Bachelorarbeit 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 Bachelorarbeit 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 Bachelorarbeit fest; er kann auch einen weiteren Gutachter bestellen. Die Bewertung hat innerhalb von sechs Wochen nach Abgabe der Bachelorarbeit 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 Bachelorzeugnis 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.

§ 15 a Mastervorzug

Studierende, die im Bachelorstudium bereits mindestens 120 LP erworben haben, können zusätzlich zu den in § 15 Abs. 1 genannten Zusatzleistungen Leistungspunkte aus einem konsekutiven Masterstudiengang am KIT im Umfang von höchstens 30 LP erwerben (Mastervorzugsleistungen). § 3 und § 4 der Prüfungsordnung bleiben davon unberührt. Die Mastervorzugsleistungen gehen nicht in die Festsetzung der Gesamt-, Fach- und Modulnoten ein. Sie werden im Transcript of Records aufgeführt und als solche gekennzeichnet sowie mit den nach § 7 vorgesehenen Noten gelistet. § 15 Absatz 2 gilt entsprechend.

§ 16 Überfachliche Qualifikationen

Neben der Vermittlung von fachlichen Qualifikationen ist der Auf- und Ausbau überfachlicher Qualifikationen im Umfang von mindestens 6 LP Bestandteil eines Bachelorstudiums. Überfachliche Qualifikationen können additiv oder integrativ vermittelt werden.

§ 17 Prüfungsausschüsse

(1) Für den Bachelorstudiengang werden Prüfungsausschüsse gebildet. Sie bestehen jeweils 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 jeweiligen 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 jeweiligen Prüfungsausschusses nimmt die laufenden Geschäfte wahr und wird durch das jeweilige Prüfungssekretariat unterstützt.

(3) Der jeweilige 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 § 19 Absatz 1 Satz 1. Er berichtet der KIT-Fakultät regelmäßig über die Entwicklung der Prüfungs- und Studienzeiten, einschließlich der Bearbeitungszeiten für die Bachelorarbeiten 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.

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(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.

§ 18 Prüfende und Beisitzende

(1) Der Prüfungsausschuss bestellt die Prüfenden. Er kann die Bestellung der/dem Vorsitzenden übertragen.

(2) Prüfende sind Hochschullehr/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.

§ 19 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 Studiengang Maschinenbau immatrikuliert wurden, haben den Antrag mit den für die Anerkennung erforderlichen Unterlagen innerhalb eines Semesters nach Immatrikulation zu stellen. Bei Unterlagen, die nicht in deutscher oder englischer Sprache vorliegen, kann eine amtlich beglaubigte Übersetzung verlangt werden. Die Beweislast dafür, dass der Antrag die Voraussetzungen für die Anerkennung nicht erfüllt, liegt beim Prüfungsausschuss.

(3) Werden Leistungen angerechnet, die nicht am KIT erbracht wurden, werden sie im Zeugnis als „anerkannt“ ausgewiesen. Liegen Noten vor, werden die Noten, soweit die Notensysteme vergleichbar sind, übernommen und in die Berechnung der Modulnoten und der Gesamtnote einbezogen. Sind die Notensysteme nicht vergleichbar, können die Noten umgerechnet werden. Liegen keine Noten vor, wird der Vermerk „bestanden“ aufgenommen.

(4) Bei der Anerkennung von Studien- und Prüfungsleistungen, die außerhalb der Bundesrepublik Deutschland erbracht wurden, sind die von der Kultusministerkonferenz und der Hochschulrektorenkonferenz gebilligten Äquivalenzvereinbarungen sowie Absprachen im Rahmen der Hochschulpartnerschaften zu beachten.

(5) Außerhalb des Hochschulsystems erworbene Kenntnisse und Fähigkeiten werden angerechnet, wenn sie nach Inhalt und Niveau den Studien- und Prüfungsleistungen gleichwertig sind, die ersetzt werden sollen und die Institution, in der die Kenntnisse und Fähigkeiten erworben wurden, ein genormtes Qualitätssicherungssystem hat. Die Anrechnung kann in Teilen versagt werden, wenn mehr als 50 Prozent des Hochschulstudiums ersetzt werden soll.

(6) Zuständig für Anerkennung und Anrechnung ist der jeweilige Prüfungsausschuss. Im Rahmen der Feststellung, ob ein wesentlicher Unterschied im Sinne des Absatz 1 vorliegt, sind die zuständigen Fachvertreter/innen zu hören. Der jeweilige Prüfungsausschuss entscheidet in Abhängigkeit von Art und Umfang der anzurechnenden Studien- und Prüfungsleistungen über die Einstufung in ein höheres Fachsemester.

II. Bachelorprüfung

§ 20 Umfang und Art der Bachelorprüfung

(1) Die Bachelorprüfung besteht aus den Modulprüfungen nach Absatz 2 sowie dem Modul Bachelorarbeit (§ 14).

(2) Es sind Modulprüfungen in folgenden Pflichtfächern abzulegen:

1. Ingenieurwissenschaftliche Grundlagen: Modul(e) im Umfang von 143 LP,
2. Vertiefung im Maschinenbau: Modul(e) im Umfang von 16 LP,
3. Überfachliche Qualifikationen im Umfang von 6 LP gemäß § 16.

Die Festlegung der zur Auswahl stehenden Module und deren Fachzuordnung werden im Modulhandbuch getroffen.

§ 21 Bestehen der Bachelorprüfung, Bildung der Gesamtnote

(1) Die Bachelorprüfung ist bestanden, wenn alle in § 20 genannten Modulprüfungen mindestens mit „ausreichend“ bewertet wurden.

(2) Die Gesamtnote der Bachelorprüfung errechnet sich als ein mit Leistungspunkten gewichteter Notendurchschnitt der Fachnoten sowie des Moduls Bachelorarbeit.

Dabei wird die Note des Moduls Bachelorarbeit mit dem doppelten Gewicht gegenüber den Noten der übrigen Fächer berücksichtigt.

(3) Haben Studierende die Bachelorarbeit mit der Note 1,0 und die Bachelorprüfung mit einem Durchschnitt von 1,2 oder besser abgeschlossen, so wird das Prädikat „mit Auszeichnung“ (with distinction) verliehen.

§ 22 Bachelorzeugnis, Bachelorurkunde, Diploma Supplement und Transcript of Records

(1) Über die Bachelorprüfung werden nach Bewertung der letzten Prüfungsleistung eine Bachelorurkunde und ein Zeugnis erstellt. Die Ausfertigung von Bachelorurkunde und Zeugnis soll nicht später als drei Monate nach Ablegen der letzten Prüfungsleistung erfolgen. Bachelorurkunde und Bachelorzeugnis werden in deutscher und englischer Sprache ausgestellt. Bachelorurkunde und Zeugnis tragen das Datum der erfolgreichen Erbringung der letzten Prüfungsleistung. Diese Dokumente werden den Studierenden zusammen ausgehändigt. In der Bachelorurkunde wird die Verleihung des akademischen Bachelorgrades beurkundet. Die Bachelorurkunde 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 jeweiligen 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 Bachelorurkunde, das Bachelorzeugnis und das Diploma Supplement einschließlich des Transcript of Records werden vom Studierendenservice des KIT ausgestellt.

III. Schlussbestimmungen

§ 23 Bescheinigung von Prüfungsleistungen

Haben Studierende die Bachelorprüfung 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.

§ 24 Aberkennung des Bachelorgrades

(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 Bachelorprüfung für „nicht bestanden“ erklärt werden.

(2) Waren die Voraussetzungen für die Zulassung zu einer Prüfung nicht erfüllt, ohne dass 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 Bachelorprüfung 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 Bachelorurkunde einzuziehen, wenn die Bachelorprüfung 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.

§ 25 Einsicht in die Prüfungsakten

(1) Nach Abschluss der Bachelorprüfung wird den Studierenden auf Antrag innerhalb eines Jahres Einsicht in das Prüfungsexemplar ihrer Bachelorarbeit, 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.

§ 26 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 Bachelorstudiengang Maschinenbau vom 28. Februar 2008 (Amtliche Bekanntmachung des KIT Nr. 78 vom 09. September 2008), zuletzt geändert durch Satzung vom 24. September 2014 (Amtliche Bekanntmachung des KIT Nr. 53 vom 01. Oktober 2014), außer Kraft.

(3) Studierende, die auf Grundlage der Studien- und Prüfungsordnung für den Bachelorstudiengang Maschinenbau vom 28. Februar 2008 (Amtliche Bekanntmachung des KIT Nr. 78 vom 09. September 2008), zuletzt geändert durch Satzung vom 24. September 2014 (Amtliche Bekanntmachung des KIT Nr. 53 vom 01. Oktober 2014), ihr Studium am KIT aufgenommen haben, können Prüfungen auf Grundlage dieser Studien- und Prüfungsordnung letztmalig am 30. September 2021 ablegen.

(4) Studierende, die auf Grundlage der Studien- und Prüfungsordnung für den Bachelorstudiengang Maschinenbau vom 28. Februar 2008 (Amtliche Bekanntmachung des KIT Nr. 78 vom 09. September 2008), zuletzt geändert durch Satzung vom 24. September 2014 (Amtliche Bekanntmachung des KIT Nr. 53 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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