## **Module Manual**

Master of Science (M.Sc.)

# Theoretical Mechanical Engineering

Cohort: Winter Term 2020

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## **Program description**

#### Content

The 4-semester research-oriented master's degree (MSc) "Theoretical Mechanical Engineering" builds on research-oriented Mechanical Engineering-oriented undergraduate degree programs (BSc). Required are in-depth knowledge in mathematics and science and engineering fundamentals. The graduates acquire basic research and methodological oriented content, including interdisciplinary orientation, mechanical engineering knowledge and associated mechanical engineering expertise to develop mathematical descriptions, analysis and synthesis of complex technical systems methods, products or processes. In this course, the program combines the two most important theoretical and methodological areas, namely the simulation technology and systems theory. For this purpose, mathematical foundations and in-depth knowledge in areas such as the Technical dynamics, control engineering, numerical and structural mechanics are learned.

### **Career prospects**

The master's degree program in Theoretical Mechanical Engineering prepares its graduates for professional and managerial positions in research and development. Through the course's focus on theory-method-oriented content and principles as well as intensive scientific thinking training, graduates are qualified for a wide field of work, especially in the area of mechanical and automotive engineering, biotechnology and medical technology, power engineering, aerospace engineering, shipbuilding, automation, materials science and related fields.

## **Learning target**

The graduates can:

- analyze and solve scientific problems, even if they are defined uncommon or incomplete and competing specifications
- formulate abstract and complex problems from a new or evolving the field of their discipline
- apply innovative methods in basic research oriented problem solving and develop new scientific methods
- identify information needs and find information
  - plan and perform theoretical and experimental investigations
- Evaluate data critically and draw conclusions
- analyze and evaluate the use of new and emerging technologies.

Graduates are able to:

- develop concepts and solutions to basic research, partly unusual problems, possibly involving other disciplines,
  - create and develop new products, processes and methods
- apply their scientific engineering judgment to work with complex, possibly incomplete information, to identify contradictions and deal with them
- classify knowledge from different fields methodically and systematically, to combine and handle

#### complexity;

- familiarize themselves systematically, and in a short time frame, with new tasks
  - To reflect systematically the non-technical implications of engineering activity and to act responsibly
- to develop solutions and further methodological skills.

### **Program structure**

The course is divided into basic research core courses and an application-specific specialization. In addition to the core subjects and mathematics, students develop in-depth knowledge in areas such as technical dynamics, control engineering, numerical and structural mechanics. To deepen the foundations of application specific specializations, modules are selected. Other technical and non-technical elective courses may be selected from the range of subjects TUHH and the University of Hamburg. During the last semester the Master thesis is carried out.

The curricular content is thus divided into six groups:

- Key skills, required courses (24 ECTS)
- Key skills, electives (24 ECTS)
- Project Work (12 ECTS)
- A specialization (18 ECTS)
- General non-technical content (12 ECTS)
- Master's thesis (30 ECTS).

The areas of specialization are:

- Biological and Medical Engineering
- · Energy Technology
- Aircraft Systems
- Maritime Technology
- Numerical and computer science
- Product development and production
- · Materials Engineering

The choice of specialization is required, its contents are closely related to the research topics of the Institute. The key skills already acquired in undergraduate study for mechanical engineering are developed within the Master's program.

## **Core qualification**

## Important

Прогсите	
Module M0523	3: Business & Management
Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	<ul> <li>Students are able to find their way around selected special areas of management within the scope of business management.</li> <li>Students are able to explain basic theories, categories, and models in selected special areas of business management.</li> <li>Students are able to interrelate technical and management knowledge.</li> </ul>
Skills	<ul> <li>Students are able to apply basic methods in selected areas of business management.</li> <li>Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.</li> </ul>
Personal Competence	
Social Competence	<ul> <li>Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems</li> </ul>
Autonomy	<ul> <li>Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.</li> </ul>
Workload in Hours	Depends on choice of courses
Credit points	

## Courses

Information regarding lectures and courses can be found in the corresponding module handbook published separately.

Module M0524: Non-technical Courses for Master		
Admission Requirements	None	
Recommended Previous Knowledge	None	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		

#### The Nontechnical Academic Programms (NTA)

imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its **teaching architecture**, in its **teaching and learning arrangements**, in **teaching areas** and by means of teaching offerings in which students can qualify by opting for **specific competences** and a **competence level** at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses.

#### The Learning Architecture

consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses.

The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles".

The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies.

#### **Teaching and Learning Arrangements**

provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses.

#### Knowledge

#### Fields of Teaching

are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way.

The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.

#### The Competence Level

of the courses offered in this area is different as regards the basic training objective

in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc.

This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life.

#### Specialized Competence (Knowledge)

Students can

- explain specialized areas in context of the relevant non-technical disciplines,
- outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area,
- different specialist disciplines relate to their own discipline and differentiate it as well as make connections,
- sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity,
- Can communicate in a foreign language in a manner appropriate to the subject.

#### **Professional Competence (Skills)**

In selected sub-areas students can

- apply basic and specific methods of the said scientific disciplines,
- aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline,
- to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner,
- justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.

# Personal Competence

Skills

#### **Personal Competences (Social Skills)**

Students will be able

- to learn to collaborate in different manner,
- to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees,
- to express themselves competently, in a culturally appropriate and gendersensitive manner in the language of the country (as far as this study-focus would be chosen),
- to explain nontechnical items to auditorium with technical background knowledge.

#### Social Competence

## **Personal Competences (Self-reliance)**

Students are able in selected areas

• to reflect on their own profession and professionalism in the context of reallife fields of application

Autonomy	<ul> <li>to organize themselves and their own learning processes</li> <li>to reflect and decide questions in front of a broad education background</li> <li>to communicate a nontechnical item in a competent way in writen form or verbaly</li> <li>to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)</li> </ul>
Workload in Hours	Depends on choice of courses
Credit points	6

#### Courses

Information regarding lectures and courses can be found in the corresponding module handbook published separately.

	9: Technical Complementary Course Core Studie ding to Subject Specific Regulations)	es for
Courses		
Title	Typ Hrs/wk C	Р
Module Responsible	Prof. Robert Seifried	
Admission Requirements	None	
Recommended Previous Knowledge	see FSPO	
Educational Objectives	After taking part successfully, students have reached the following learning	results
Professional Competence		
Knowledge	see FSPO	
Skills	see FSPO	
Personal Competence		
Social Competence	see FSPO	
Autonomy	see FSPO	
<b>Workload in Hours</b>	Depends on choice of courses	
Credit points	6	
Assignment for the Following Curricula	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory	/

Courses					
<b>Title</b> Finite Element Method	s (L0291)		<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3
Finite Element Method	s (L0804)		Recitation (large)	Section 2	3
Module Responsible	Prof. Otto von Estorff				
Admission Requirements	None				
Recommended Previous Knowledge	Kinematics, Dynamics)				Hydrostatio
Educational Objectives	LATTER TAKING NATT SUCCES	ssfully, students h	nave reached	the following learr	ning results
Professional Competence					
Knowledge	The students possess a element method and a basis of the method.				
Skills	The students are capa finite elements, assem resulting system of equ	bling the corres			
Personal Competence Social Competence	Chiralamba aan iirankiin ai	mall groups on sp	ecific problem	ns to arrive at join	t solutions.
Autonomy	The students are able and develop own finite are critically scrutinized	element routines			
Workload in Hours	Independent Study Tim	e 124, Study Tim	e in Lecture 5	6	
Credit points					
Course achievement	CompulsorBonus No 20 %	<b>Form</b> Midterm	D	escription	
Examination	Written exam				
Examination duration and scale	120 min				
-	Civil Engineering: Core Energy Systems: Core Aircraft Systems Engine Aircraft Systems Engine	qualification: Elec eering: Specialisa	tive Compulso tion Aircraft S	ystems: Elective (	

Assignment for the Following Curricula	Mechatronics: Core qualification: Compulsory
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Course L0291: Finite Element Methods		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Otto von Estorff	
Language	EN	
Cycle	WiSe	
Content	- General overview on modern engineering - Displacement method - Hybrid formulation - Isoparametric elements - Numerical integration - Solving systems of equations (statics, dynamics) - Eigenvalue problems - Non-linear systems - Applications - Programming of elements (Matlab, hands-on sessions) - Applications	
Literature	Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin	

Course L0804: Finite Element Methods	
Тур	Recitation Section (large)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0846	6: Control Systems The	ory and Desig	n	
Courses				
<b>Title</b> Control Systems Theor Control Systems Theor		<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 4 2
Module Responsible	Prof. Herbert Werner	(Siliali)		
Admission Requirements	None			
Recommended Previous Knowledge	Introduction to Control Systems			
Educational Objectives	TATTOT TAKING NATT CHECKECTHING CTHE	dents have reached	the following lear	ning results
Professional Competence				
Knowledge	<ul> <li>Students can explain how space models; they can in external excitation as traject.</li> <li>They can explain the syste their relationship to state for they can explain the signification.</li> <li>They can explain observer achieve tracking and disturent they can extend all of the action.</li> <li>They can explain the z-the transform.</li> <li>They can explain state space time systems.</li> <li>They can explain the expensivation systems, and how the idenormal equation.</li> <li>They can explain how a discrete-time impulse response.</li> </ul>	nterpret the system ctories in state space m properties controlled back and state escance of a minimal rebased state feedback and state feedback and state feedback and its respectively. The controlled back and transform and its remodels and transform identification problem state space model	response to inition response to inition response to inition respect realisation ck and how it call relationship with fer function model can be solved	rvability, and cively  n be used to ems the Laplace els of discrete by solving a
Skills	<ul> <li>Students can transform tranvice versa</li> <li>They can assess controllar realisations</li> <li>They can design LQG control They can carry out a control time domain, and decide with the domain transfedynamic systems from expedynamic systems from expedynamic systems from expedit the Control Toolbox, System Idea</li> </ul>	ability and observa ollers for multivariable coller design both in hich is appropriate to r function models erimental data ese tasks using sta	bility and const	ruct minima and discrete ing rate e models o
Personal Competence				
Social Competence	ļ			
	Students can obtain information documentation, experiment guide			
	[15]			

Autonomy	They can assess their knowledge in weekly on-line tests and thereby control their learning progress.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Electrical Engineering: Core qualification: Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory

Course L0656: Con	trol Systems Theory and Design
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	State space methods (single-input single-output)  State space models and transfer functions, state feedback Coordinate basis, similarity transformations Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem Controllability and pole placement State estimation, observability, Kalman decomposition Observer-based state feedback control, reference tracking Transmission zeros Optimal pole placement, symmetric root locus Multi-input multi-output systems Transfer function matrices, state space models of multivariable systems, Gilbert realization Poles and zeros of multivariable systems, minimal realization Closed-loop stability Pole placement for multivariable systems, LQR design, Kalman filter Digital Control Discrete-time systems: difference equations and z-transform Discrete-time state space models, sampled data systems, poles and zeros Frequency response of sampled data systems, choice of sampling rate System identification and model order reduction Least squares estimation, ARX models, persistent excitation Identification of state space models, subspace identification Balanced realization and model order reduction Case study Modelling and multivariable control of a process evaporator using Matlab and Simullink Software tools
Literature	<ul> <li>Matlab/Simulink</li> <li>Werner, H., Lecture Notes "Control Systems Theory and Design"</li> <li>T. Kailath "Linear Systems", Prentice Hall, 1980</li> <li>K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997</li> <li>L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999</li> </ul>

Course L0657: Con	Course L0657: Control Systems Theory and Design	
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1204	4: Modelling and Optimiz	zation in Dyna	mics	
Courses				
<b>Title</b> Flexible Multibody Syst Optimization of dynam		<b>Typ</b> Lecture Lecture	<b>Hrs/wk</b> 2 2	<b>CP</b> 3 3
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous Knowledge	<ul> <li>Mechanics I, II, III, IV</li> </ul>	tems		
Educational Objectives	After taking part successfully, stud	ents have reached th	e following learr	ning results
Professional Competence				
Knowledge	Students demonstrate basic knowl and analysis of complex rigid an optimizing dynamic systems after s	d flexible multibody	systems and	
	Students are able			
	+ to think holistically			
Skills	+ to independently, securly and c the dynamics of rigid and flexible n		optimize basic	problems of
	+ to describe dynamics problems r	nathematically		
	+ to optimize dynamics problems			
Personal Competence				
	Students are able to			
Social Competence	+ solve problems in heterogeneous results.	us groups and to d	ocument the co	orresponding
	Students are able to			
	+ assess their knowledge by mean	s of exercises.		
Autonomy	+ acquaint themselves with the r tasks.	necessary knowledge	to solve resea	rch oriented
Workload in Hours	Independent Study Time 124, Stud	y Time in Lecture 56		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and scale				
Scarc				

	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory
Assignment for	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
	Product Development, Materials and Production: Core qualification: Elective
	Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory

Course L1632: Flexible Multibody Systems		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Robert Seifried, Dr. Alexander Held	
Language	DE	
Cycle	WiSe	
Content	<ol> <li>Basics of Multibody Systems</li> <li>Basics of Continuum Mechanics</li> <li>Linear finite element modelles and modell reduction</li> <li>Nonlinear finite element Modelles: absolute nodal coordinate formulation</li> <li>Kinematics of an elastic body</li> <li>Kinetics of an elastic body</li> <li>System assembly</li> </ol>	
Literature	Schwertassek, R. und Wallrapp, O.: Dynamik flexibler Mehrkörpersysteme. Braunschweig, Vieweg, 1999.  Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.  Shabana, A.A.: Dynamics of Multibody Systems. Cambridge Univ. Press, Cambridge, 2004, 3. Auflage.	

Course L1633: Opt	imization of dynamical systems
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	<ol> <li>Formulation and classification of optimization problems</li> <li>Scalar Optimization</li> <li>Sensitivity Analysis</li> <li>Unconstrained Parameter Optimization</li> <li>Constrained Parameter Optimization</li> <li>Stochastic optimization</li> <li>Multicriteria Optimization</li> <li>Topology Optimization</li> </ol>
Literature	Bestle, D.: Analyse und Optimierung von Mehrkörpersystemen. Springer, Berlin, 1994.  Nocedal, J., Wright, S.J.: Numerical Optimization. New York: Springer, 2006.

Module M1306	6: Control Lab C			
Courses				
Title Control Lab IX (L1836) Control Lab VII (L1834) Control Lab VIII (L1835)	)	<b>Typ</b> Practical Course Practical Course Practical Course	Hrs/wk 1 1 1	<b>CP</b> 1 1 1
Module Responsible	I Prof. Hernert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	H2 and H-infinity optimal control	st control		
Educational Objectives	After taking part successfully, students	have reached the fol	lowing learn	ing results
Professional Competence				
Knowledge	<ul> <li>Students can explain the difference simulation and experimental valid</li> </ul>		tion of a co	ontrol lop in
Skills	<ul> <li>Students are capable of applying System Identification Toolbox) to for controller synthesis</li> <li>They are capable of using stand for the design and implementation.</li> <li>They are capable of using stand Toolbox) for the mixed-sensitivity optimal controllers</li> <li>They are capable of representing implementing a robust controller.</li> <li>They are capable of using stand Toolbox) for the design and the controllers.</li> </ul>	identify a dynamic identify a dynamic identify a dynamic identification of LQG controllers dard software tools design and the implies model uncertainty dard software tools	model that of Matlab Content (Matlab Rollementation ), and of de	can be used crol Toolbox)  oust Control of H-infinity esigning and oust Control
Personal Competence				
Social Competence	<ul> <li>Students can work in teams to results</li> </ul>	o conduct experime	ents and do	cument the
Autonomy	<ul> <li>Students can independently ca validate control loops</li> </ul>	erry out simulation	studies to	design and
<b>Workload in Hours</b>	Independent Study Time 48, Study Time	e in Lecture 42		
Credit points	3			
Course achievement	None			
Examination	Written elaboration			
Examination duration and scale	1			

	Electrical Engineering: Specialisation Control and Power Systems Engineering:
	Elective Compulsory
Assignment for	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
the Following	Mechatronics: Specialisation System Design: Elective Compulsory
Curricula	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory

Course L1836: Control Lab IX	
Тур	Practical Course
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Herbert Werner, Patrick Göttsch, Adwait Datar
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

Course L1834: Control Lab VII	
Тур	Practical Course
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Herbert Werner, Patrick Göttsch
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

Course L1835: Con	Course L1835: Control Lab VIII			
Тур	Practical Course			
Hrs/wk	1			
СР	1			
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14			
Lecturer	Prof. Herbert Werner, Patrick Göttsch, Adwait Datar			
Language	EN			
Cycle	WiSe/SoSe			
	One of the offered experiments in control theory.			
Literature	Experiment Guides			

Module M1150	0: Continuum Mechanics			
Courses				
<b>Title</b> Continuum Mechanics	(L1533)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3
Continuum Mechanics	Exercise (L1534)	Recitation (small)	Section 2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	INONE			
Recommended Previous Knowledge	(forces and moments, stress, line			
Educational Objectives	After taking part successfully, studer	nts have reached t	he following lear	ning results
Professional Competence				
Knowledge	The students can explain the fundable behavior of materials.	amental concepts	to calculate the	mechanica
Skills	The students can set up balance la specific aspects, both in applied cont			on theory to
Personal Competence Social Competence	The students are able to develop sol form and to develop ideas further.	lutions, to present	them to specialis	sts in writter
Autonomy	The students are able to assess the independently and on their own continuum mechanics and acquire the	identify and solv	e problems in	
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 50	5	
Credit points	6			
Course achievement	INODA			
	Written exam			
Examination duration and scale	45 min			
	Materials Science: Specialisation Mod Mechanical Engineering and Mar Compulsory Mechatronics: Technical Complemen Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation	nagement: Special tary Course: Elect on Artificial Organ nation Implants ar tion Medical Tech	alisation Materia ive Compulsory s and Regenerati nd Endoprosthes nology and Con	ve Medicine: es: Elective trol Theory:

	Compulsory						
Product	Development,	Materials	and	Production:	Core	qualification:	Elective
Compul							
Theoret	cal Mechanical	Engineerir	ıg: Te	chnical Com	plemei	ntary Course:	Elective
Compul	sory						
Theoret	cal Mechanical E	Engineering	: Core	qualification	: Electi	ve Compulsory	,

Course L1533: Con	tinuum Mechanics
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul> <li>kinematics of undeformed and deformed bodies</li> <li>balance equations (balance of mass, balance of energy,)</li> <li>stress states</li> <li>material modelling</li> </ul>
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer

Course L1534: Con	tinuum Mechanics Exercise
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul> <li>kinematics of undeformed and deformed bodies</li> <li>balance equations (balance of mass, balance of energy,)</li> <li>stress states</li> <li>material modelling</li> </ul>
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer

Module M075	L: Vibration Theory
Courses	
<b>Title</b> Vibration Theory (L070	Typ Hrs/wk CP Integrated Lecture 4 6
Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	tnem furtner.
	Students are able to denote methods of Vibration Theory and develop them further.
Personal Competence	
I	Students can reach working results also in groups.
	Students are able to approach individually research tasks in Vibration Theory.
	Independent Study Time 124, Study Time in Lecture 56
Credit points Course	
achievement	None
Examination	Written exam
Examination duration and scale	2 Hours
the Following	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L0701: Vibr	Course L0701: Vibration Theory		
Тур	Integrated Lecture		
Hrs/wk	4		
СР	6		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
Lecturer	Prof. Norbert Hoffmann		
Language	DE/EN		
Cycle	WiSe		
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Oscillations and Waves.		
Literature	K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. Springer Verlag, 2013.		

Module M07: Equations	14: Numerical Treatment of Ordinary Differenti	al
Courses		
	Typ Hrs/wk CP of Ordinary Differential Equations (L0576)  Recitation (small)  CP  2 3  Recitation (small)	
Module Responsible	Prof. Daniel Ruprecht	
Admission Requirements	None	
Recommended Previous Knowledge	<ul> <li>Mathematik I, II, III für Ingenieurstudierende (deutsch oder englisch) o Analysis &amp; Lineare Algebra I + II sowie Analysis III für Technomathematike</li> <li>Basic MATLAB knowledge</li> </ul>	
Educational Objectives	After taking part successfully, students have reached the following learning resul	ts
Professional Competence		
Knowledge	<ul> <li>list numerical methods for the solution of ordinary differential equations a explain their core ideas,</li> <li>repeat convergence statements for the treated numerical methods (include the prerequisites tied to the underlying problem),</li> <li>explain aspects regarding the practical execution of a method.</li> <li>select the appropriate numerical method for concrete problems, implementation that the numerical algorithms efficiently and interpret the numerical results</li> </ul>	ding
Skills	<ul> <li>implement (MATLAB), apply and compare numerical methods for the solut of ordinary differential equations,</li> <li>to justify the convergence behaviour of numerical methods with respect the posed problem and selected algorithm,</li> <li>for a given problem, develop a suitable solution approach, if necessary by composition of several algorithms, to execute this approach and to critic evaluate the results.</li> </ul>	t to
Personal Competence	Students are able to	
Social Competence	<ul> <li>work together in heterogeneously composed teams (i.e., teams fr different study programs and background knowledge), explain theoret foundations and support each other with practical aspects regarding implementation of algorithms.</li> </ul>	ica
Autonomy	<ul> <li>to assess whether the supporting theoretical and practical excercises better solved individually or in a team,</li> <li>to assess their individual progress and, if necessary, to ask questions a seek help.</li> </ul>	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	

Credit points	6
Course achievement	
Examination	Written exam
Examination duration and scale	90 min
the Following	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Computer Science: Specialisation III. Mathematics: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Mathematical Modelling in Engineering: Theory, Numerics, Applications: Specialisation I. Numerics (TUHH): Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0576: Numerical Treatment of Ordinary Differential Equations			
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Daniel Ruprecht		
Language	DE/EN		
Cycle	SoSe		
Content	Numerical methods for Initial Value Problems  • single step methods • multistep methods • stiff problems • differential algebraic equations (DAE) of index 1  Numerical methods for Boundary Value Problems • multiple shooting method • difference methods • variational methods		
Literature	<ul> <li>E. Hairer, S. Noersett, G. Wanner: Solving Ordinary Differential Equations I: Nonstiff Problems</li> <li>E. Hairer, G. Wanner: Solving Ordinary Differential Equations II: Stiff and Differential-Algebraic Problems</li> </ul>		

Course L0582: Nun	Course L0582: Numerical Treatment of Ordinary Differential Equations		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Daniel Ruprecht		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M120 methods	03: Applied Dynamic	cs: Numerical and	l experimental
methods			
Courses			
		<u>-</u>	/ 1
<b>Title</b> Lab Applied Dynamics	(11621)	<b>Typ</b> Practical Course	Hrs/wk CP 3 3
Applied Dynamics (L16		Lecture	2 3
		20014.0	
модије Responsible	Prof. Robert Seifried		
Admission			
Requirements	None		
Recommended	Mathematics I, II, III, Mechanics	I, II, III, IV	
Previous		y Differential Equations	
	Numerical Treatment of Ordinar	y Differential Equations	
Educational Objectives	After taking part successfully, st	tudents have reached the follo	owing learning results
Professional	<u> </u>		
Competence			
	Students can represent the mo	est important methods of dyr	namics after successfu
Knowledge	completion of the module Techr	nical dynamics and have a goo	
	main concepts in the technical o	dynamics.	
	Students are able		
	+ to think holistically		
	+ to independently, securly an	d critically analyze and optin	nize basic problems o
Skills	the dynamics of rigid and flexib	le multibody systems	·
	+ to describe dynamics problem	ns mathematically	
		-	
	+ to investigate dynamics probl	ems both experimentally and	numerically
Personal			
Competence			
	Students are able to		
	+ solve problems in heteroge	neous groups and to docum	ent the corresponding
Social Competence	results.	g. cups and to decam.	
	Students are able to		
	+ assess their knowledge by me	eans of exercises and experim	ients.
		·	
Autonomy	+ acquaint themselves with th tasks.	e necessary knowledge to s	olve research oriented
	lasks.		
Workload in House	I Independent Study Time 110, S	tudy Time in Lecture 70	
Credit points	<u> </u>	tady Time in Lecture 70	
Credit points		B '	
Course	CompulsorBonus Form Subject	<b>Descrip</b> theoretical and various	
achievement	Yes None practica	VARSIICH	e Fachlabor
Examination	Written exam		
Examination			
duration and			
l	150 111111		

scale	
Assignment for	
the Following	Theoretical Mechanical Engineering: Core qualification: Compulsory
Curricula	

Course L1631: Lab	Applied Dynamics
Тур	Practical Course
Hrs/wk	3
СР	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Marc-André Pick, Dr. Marc-André Pick
Language	DE
Cycle	SoSe
Content	Practical exercises are performed in groups. The examples are taken from different areas of applied dynamics, such as numerical simulation, experimental validation and experimental vibration analysis.
Literature	Schiehlen, W.; Eberhard, P.: Technische Dynamik, 4. Auflage, Vieweg+Teubner: Wiesbaden, 2014.

Course L1630: App	lied Dynamics		
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Robert Seifried		
Language	DE		
Cycle	SoSe		
Content	<ol> <li>Modelling of Multibody Systems</li> <li>Basics from kinematics and kinetics</li> <li>Constraints</li> <li>Multibody systems in minimal coordinates</li> <li>State space, linearization and modal analysis</li> <li>Multibody systems with kinematic constraints</li> <li>Multibody systems as DAE</li> <li>Non-holonomic multibody systems</li> <li>Experimental Methods in Dynamics</li> </ol>		
Literature	Schiehlen, W.; Eberhard, P.: Technische Dynamik, 4. Auflage, Vieweg+Teubner: Wiesbaden, 2014.  Woernle, C.: Mehrkörpersysteme, Springer: Heidelberg, 2011.  Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.		

Module M0752	2: Nonlinear Dynamics			
Courses				
<b>Title</b> Nonlinear Dynamics (L	.0702)	<b>Typ</b> Integrated Lecture	Hrs/wk 4	<b>CP</b> 6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	Linear Algebra			
Educational Objectives	After taking part successfully, students h	nave reached the follo	wing learni	ng results
Professional Competence				
Knowledge	to develop and research new terms and	concepts.		
Skills	Dynamics and to develop novel methods		cesures of	Nonlinear
Personal Competence				
Social Competence	Students can reach working results also	= .		
Autonomy	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.			
	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
	Aircraft Systems Engineering: Specialisa International Management and Engineer Compulsory Mechanical Engineering and Managem Compulsory Mechatronics: Specialisation System Des Mechatronics: Specialisation Intelligent S	ring: Specialisation II. nent: Specialisation I sign: Elective Compuls systems and Robotics	Mechatronic  Sory  Elective C	ics: Elective cs: Elective ompulsory
Assignment for the Following Curricula	Biomedical Engineering: Specialisation A Elective Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation Elective Compulsory Product Development, Materials and Compulsory Theoretical Mechanical Engineering: To Compulsory Theoretical Mechanical Engineering: Compulsory	Medical Technology  Management and Bu  Production: Core	and Cont and Cont usiness Adn qualificatio tary Cours	es: Elective rol Theory: ninistration: n: Elective ee: Elective

Course L0702: Nonlinear Dynamics		
Тур	Integrated Lecture	
Hrs/wk	4	
СР	6	
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Norbert Hoffmann	
Language	DE/EN	
Cycle	SoSe	
Content	Fundamentals of Nonlinear Dynamics.	
Literature	S. Strogatz: Nonlinear Dynamics and Chaos. Perseus, 2013.	

Courses				
<b>Title</b> Linear and Nonlinear S	System Identification (L0660)	<b>Typ</b> Lecture	<b>Hrs/wk (</b> 2 3	CP S
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul> <li>Classical control (frequency response, root locus)</li> <li>State space methods</li> <li>Discrete-time systems</li> <li>Linear algebra, singular value decomposition</li> <li>Basic knowledge about stochastic processes</li> </ul>			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	<ul> <li>Students can explain the general framework of the prediction error method and its application to a variety of linear and nonlinear model structures</li> <li>They can explain how multilayer perceptron networks are used to mode nonlinear dynamics</li> <li>They can explain how an approximate predictive control scheme can be based on neural network models</li> <li>They can explain the idea of subspace identification and its relation to Kalma realisation theory</li> </ul>			
Skills	<ul> <li>Students are capable of applying the predicition error method to the experimental identification of linear and nonlinear models for dynamic systems</li> <li>They are capable of implementing a nonlinear predictive control scheme based on a neural network model</li> <li>They are capable of applying subspace algorithms to the experimental identification of linear models for dynamic systems</li> <li>They can do the above using standard software tools (including the Matlal System Identification Toolbox)</li> </ul>			
Personal Competence				
Social Competence	Students can work in mixed grou	ups on specific problems	to arrive at joint s	olutions.
Autonomy	Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.			
Workload in Hours	Independent Study Time 62, Stu	idy Time in Lecture 28		
Credit points	1			
Course achievement	LNODE			
Examination	Oral exam			
Examination duration and scale	30 min			
	Electrical Engineering: Special Elective Compulsory Mechatronics: Specialisation Inte		-	_

	Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
Assignment for	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective			
the Following	Compulsory			
Curricula	Biomedical Engineering: Specialisation Medical Technology and Control Theory:			
	Compulsory			
	Biomedical Engineering: Specialisation Management and Business Administration:			
	Elective Compulsory			
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective			
	Compulsory			
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory			

Course L0660: Linear and Nonlinear System Identification			
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Herbert Werner		
Language	EN		
Cycle	SoSe		
Content	<ul> <li>Prediction error method</li> <li>Linear and nonlinear model structures</li> <li>Nonlinear model structure based on multilayer perceptron network</li> <li>Approximate predictive control based on multilayer perceptron network model</li> <li>Subspace identification</li> </ul>		
Literature	<ul> <li>Lennart Ljung, System Identification - Theory for the User, Prentice Hall 1999</li> <li>M. Norgaard, O. Ravn, N.K. Poulsen and L.K. Hansen, Neural Networks for Modeling and Control of Dynamic Systems, Springer Verlag, London 2003</li> <li>T. Kailath, A.H. Sayed and B. Hassibi, Linear Estimation, Prentice Hall 2000</li> </ul>		

Module M0657	7: Computational Fluid	Dynamics II		
Courses				
Title Computational Fluid Dynamics II (L0237)		<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3
Computational Fluid Dy	ynamics II (L0421)	Recitation (large)	Section 2	3
Kesponsible				
Admission Requirements	None			
Knowledge	Basics of computational and gener			
Educational Objectives	After taking part successfully, stud	dents have reached t	he following learr	ing results
Professional Competence				
Knowledge	Establish a thorough understanding of Finite-Volume approaches. Familiarise with details of the theoretical background of complex CFD algorithms.			
Skills	Ability to manage of interface problems and build-up of coding skills. Ability to evaluate, assess and benchmark different solution options.			
Personal Competence				
Social Competence	Practice of team working during te	eam exercises.		
Autonomy	Indenpendent analysis of specific solution approaches.			
<b>Workload in Hours</b>	Independent Study Time 124, Stud	dy Time in Lecture 56	5	
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	0.5h-0.75h			
Assignment for the Following Curricula	Energy Systems: Core qualification Naval Architecture and Ocean Eng Theoretical Mechanical Engineer Compulsory Theoretical Mechanical Engineerin Process Engineering: Specialisatio	ineering: Core qualifiing: Technical Comp g: Core qualification:	cation: Elective Colementary Cour	se: Elective

Course L0237: Computational Fluid Dynamics II						
Тур	Lecture					
Hrs/wk	2					
СР	3					
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28					
Lecturer	Prof. Thomas Rung					
Language	DE/EN					
Cycle	Cycle SoSe					
Content Computational Modelling of complex single- and multiphase flows order approximations for unstructured grids and mehsless particle-base						
Literature	1) Vorlesungsmanuskript und Übungsunterlagen  2) J.H. Ferziger, M. Peric: Computational Methods for Fluid Dynamics, Springer					

Course L0421: Computational Fluid Dynamics II						
Тур	Recitation Section (large)					
Hrs/wk 2						
СР	3					
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28					
Lecturer	Prof. Thomas Rung					
Language	DE/EN					
Cycle	SoSe					
Content	See interlocking course					
Literature	See interlocking course					

Courses											
<b>Title</b> Optimal and Robust Co	ontrol (	L0658)					<b>p</b> ture citation	Soction	Hrs/wk	<b>CP</b> 3	
Optimal and Robust Co	ontrol (	L0659)					nall)	Section	2	3	
Module Responsible	Prof.	Herbert \	Werner								
Admission Requirements	None										
Recommended Previous Knowledge	•	State s	al contro pace me algebra,	ethods				us)			
Educational Objectives	After	taking p	art succ	essfully	, studer	nts have	reached	the foll	owing lear	ning re	sults
Professional Competence											
Knowledge	•	solution They control state estability They control case of They control lends it They control can gua They u	n of LQ p an expla stimation an expla y and pe an expla can expla can expla arantee	oroblem ain the n. ain how design polain how obust coin how stability and how	the Hone con LQC oroblem wode ontrolle or and page and page analys	between 2 and Heatraints. Godesign and the seriorman is and seriorman is an accordance in the seriorman is a seriorman in the seriorman in the seriorman is a seriorman in the seriorm	en optimed in the second secon	nal state norms m can be n be rep nin theor n uncert s conditi	feedback are used formulate resented if em - a rob ain plant. ons on fe	and o to rep ed as s n a wa ust cor	ptim rese speci y th
Skills	•	multiva They a form of it. They al control carrying They al system They a matrix They c	ariable pre capal fa gene re capal loops i g out a r re capal n, and of re capal inequali	lant moble of related of the color of colors of colors of colors of feties (LM) out all	odels. represe plant, a ranslatir nstraint sensitivi construc ing a mi formulat (II), and II of the	nting a and of us as on closty design ting an acceptance of the control of using an acceptance of using a control of using a contr	H2 or H sing star and freq osed-loo n. LFT unce ective ro lysis and standar	l-infinity ndard so uency do p sensit ertainty bust cor d synthe d LMI-so	LQG codesign professional special spec	oblem ols for s cification tions, a an und ons as olving t	in the solving and serta lines them
Personal Competence											
Social Competence				_	•	•	-		rive at joir provided (I		
Autonomy									problems.		note

<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
the Following	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Product Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L0658: Optimal and Robust Control							
Тур	Lecture						
Hrs/wk	2						
СР	3						
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28						
Lecturer	Prof. Herbert Werner						
Language	EN						
Cycle	SoSe						
Content	<ul> <li>Optimal regulator problem with finite time horizon, Riccati differential equation</li> <li>Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system</li> <li>Kalman's identity, phase margin of LQR controllers, spectral factorization</li> <li>Optimal state estimation, Kalman filter, LQG control</li> <li>Generalized plant, review of LQG control</li> <li>Signal and system norms, computing H2 and H∞ norms</li> <li>Singular value plots, input and output directions</li> <li>Mixed sensitivity design, H∞ loop shaping, choice of weighting filters</li> <li>Case study: design example flight control</li> <li>Linear matrix inequalities, design specifications as LMI constraints (H2, H∞ and pole region)</li> <li>Controller synthesis by solving LMI problems, multi-objective design</li> <li>Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty</li> </ul>						
Literature	<ul> <li>Werner, H., Lecture Notes: "Optimale und Robuste Regelung"</li> <li>Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994</li> <li>Skogestad, S. and I. Postlewhaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996</li> <li>Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988</li> <li>Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998</li> </ul>						

Course L0659: Opt	Course L0659: Optimal and Robust Control					
Тур	Recitation Section (small)					
Hrs/wk	2					
СР	3					
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28					
<b>Lecturer</b> Prof. Herbert Werner						
Language	EN					
Cycle	SoSe					
Content	See interlocking course					
Literature	See interlocking course					

## Module M1339: Design optimization and probabilistic approaches in structural analysis

Structurar and	,5.5					
Courses						
Analysis (L1873) Design Optimization a	nd Probabilistic Approaches in Structural	<b>Typ</b> Lecture Recitation	Hrs/wk 2 Section 2	<b>CP</b> 3		
Analysis (L1874)		(large)				
Module Responsible	Prof. Benedikt Kriegesmann					
Admission Requirements	LNIANA					
Recommended Previous Knowledge	Technical mechanics     Higher math					
Educational Objectives	LATTOR FAKING NART CHECKDECTHING CTHINDNE	s have reached	the following learn	ing results		
Professional Competence						
Knowledge	<ul> <li>Design optimization         <ul> <li>Gradient based methods</li> <li>Genetic algorithms</li> <li>Optimization with constraints</li> <li>Topology optimization</li> </ul> </li> <li>Reliability analysis         <ul> <li>Stochastic basics</li> <li>Monte Carlo methods</li> <li>Semi-analytic approaches</li> </ul> </li> <li>robust design optimization         <ul> <li>Robustness measures</li> <li>Coupling of design optimization and reliability analysis</li> </ul> </li> </ul>					
Skills	<ul> <li>Application of optimization algo of structures</li> <li>Programming with Matlab</li> <li>Implementation of algorithms</li> <li>Debugging</li> </ul>	orithms and prob	abilistic methods i	n the design		
Personal Competence						
<ul> <li>Social Competence</li> <li>Team work</li> <li>Oral explanation of the the work</li> </ul>						
Autonomy	<ul> <li>Application of methods learned in the framework of a home work</li> <li>Familiarizing with source code provided</li> <li>Description of approaches and results</li> </ul>					
<b>Workload in Hours</b>	Independent Study Time 124, Study T	ime in Lecture 5	6			
Credit points	6					
Course achievement	None					
Examination	Written elaboration					
Examination						

duration and	. •							
scale								
	craft Systems Engineering: Specialisation Air Transportation Systems: Elective mpulsory							
Assignment for	Product Development, Materials and Production: Core qualification: Elective							
the Following								
Curricula	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory							

Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Benedikt Kriegesmann
Language	DE
Cycle	SoSe
	In the course the theoretic basics for design optimization and reliability analysis are taught, where the focus is on the application of such methods. The lectures will consist of presentations as well as computer exercises. In the computer exercises, the methods learned will be implemented in Matlab for understanding the practical realization.  The following contents will be considered:  • Design optimization  • Gradient based methods  • Genetic algorithms  • Optimization with constraints  • Topology optimization  • Reliability analysis  • Stochastic basics  • Monte Carlo methods  • Semi-analytic approaches  • robust design optimization  • Robustness measures  • Coupling of design optimization and reliability analysis
	[1] Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011. [2] Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley & Sons New York/Chichester, UK, 2000.

Course L1874: Design Optimization and Probabilistic Approaches in Structural Analysis						
Тур	Recitation Section (large)					
Hrs/wk	2					
СР	3					
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28					
<b>Lecturer</b> Prof. Benedikt Kriegesmann						
Language	DE					
Cycle	SoSe					
Content	Matlab exercises complementing the lecture					
Literature	siehe Vorlesung					

Module M0604	4: High-Order F	EM				
Courses						
<b>Title</b> High-Order FEM (L028) High-Order FEM (L028)			<b>Typ</b> Lecture Recitation (large)	Hrs/wk 3 Section 1	<b>CP</b> 4 2	
Module Responsible	Prof. Alexander Düste	er				
Admission Requirements	None					
Recommended Previous Knowledge	Knowledge of partial	differential equation	ons is recomm	ended.		
Educational Objectives	After taking part succ	cessfully, students	have reached	the following learr	ning results	
Professional						
Competence Knowledge	Students are able to + give an overview of the different (h, p, hp) finite element procedures.					
Skills	Students are able to + apply high-order fir + select for a giver procedure. + critically judge resu + transfer their know	n problem of stru ults of high-order f	ctural mechar nite elements.	nics a suitable fir		
Personal Competence						
Social Competence	Students are able to + solve problems in results.	heterogeneous g	groups and to	document the co	orresponding	
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research orientasks.					
Workload in Hours	Independent Study T	ime 124, Study Tir	ne in Lecture 5	66		
Credit points	6					
Course achievement	CompulsorBonus No 10 %	<b>Form</b> Presentation		<b>Description</b> orschendes Lerne	n	
Examination	Written exam					
Examination duration and scale	and 120 min					
	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Product Develop and Production: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development Production: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory					

I	Curricula	Product	Development,	Materials	and	Production:	Core	qualification:	Elective
ı		Compuls							
		Naval Ar	chitecture and (	Ocean Engir	neerir	ig: Core quali	ficatior	n: Elective Com	pulsory
		Theoretic	cal Mechanical	Engineerir	ıg: Te	echnical Com	pleme	ntary Course:	Elective
		Compuls	ory						
		Theoretic	cal Mechanical E	Engineering	: Core	e qualification	: Elect	ive Compulsory	,

Course L0280: High	n-Order FEM
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	<ol> <li>Introduction</li> <li>Motivation</li> <li>Hierarchic shape functions</li> <li>Mapping functions</li> <li>Computation of element matrices, assembly, constraint enforcement and solution</li> <li>Convergence characteristics</li> <li>Mechanical models and finite elements for thin-walled structures</li> <li>Computation of thin-walled structures</li> <li>Error estimation and hp-adaptivity</li> <li>High-order fictitious domain methods</li> </ol>
Literature	[1] Alexander Düster, High-Order FEM, Lecture Notes, Technische Universität Hamburg-Harburg, 164 pages, 2014 [2] Barna Szabo, Ivo Babuska, Introduction to Finite Element Analysis – Formulation, Verification and Validation, John Wiley & Sons, 2011

Course L0281: High-Order FEM	
Тур	Recitation Section (large)
Hrs/wk	1
СР	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M071:	1: Numerical Mathematics II
Courses	
<b>Title</b> Numerical Mathematic	Recitation Section
Module Responsible	Prof Sahina La Borna
Admission Requirements	None
Recommended Previous Knowledge	Numerical Mathematics I     MATI AB knowledge
Educational Objectives	
Professional Competence Knowledge	<ul> <li>Students are able to</li> <li>name advanced numerical methods for interpolation, integration, linear least squares problems, eigenvalue problems, nonlinear root finding problems and explain their core ideas,</li> <li>repeat convergence statements for the numerical methods,</li> <li>sketch convergence proofs,</li> <li>explain practical aspects of numerical methods concerning runtime and</li> </ul>
Skills	<ul> <li>implement, apply and compare advanced numerical methods in MATLAB,</li> <li>justify the convergence behaviour of numerical methods with respect to the problem and solution algorithm and to transfer it to related problems,</li> <li>for a given problem, develop a suitable solution approach, if necessary through composition of several algorithms, to execute this approach and to critically evaluate the results</li> </ul>
Personal Competence Social Competence	• work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretica foundations and support each other with practical aspects regarding the implementation of algorithms.
Autonomy	<ul> <li>to assess whether the supporting theoretical and practical excercises are better solved individually or in a team,</li> <li>to assess their individual progess and, if necessary, to ask questions and</li> </ul>

	seek help.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	25 min
_	Computer Science: Specialisation III. Mathematics: Elective Compulsory Computational Science and Engineering: Specialisation III. Mathematics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L0568: Nun	nerical Mathematics II	
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke	
Language	DE/EN	
Cycle	SoSe	
Content	<ol> <li>Error and stability: Notions and estimates</li> <li>Interpolation: Rational and trigonometric interpolation</li> <li>Quadrature: Gaussian quadrature, orthogonal polynomials</li> <li>Linear systems: Perturbation theory of decompositions, structured matrices</li> <li>Eigenvalue problems: LR-, QD-, QR-Algorithmus</li> <li>Krylov space methods: Arnoldi-, Lanczos methods</li> </ol>	
Literature	<ul> <li>Stoer/Bulirsch: Numerische Mathematik 1, Springer</li> <li>Dahmen, Reusken: Numerik für Ingenieure und Naturwissenschaftler, Springer</li> </ul>	

Course L0569: Numerical Mathematics II	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module Responsible  Admission Requirements  Recommended Previous Knowledge  Educational Objectives  Professional Competence  Knowledge  Knowledge  Knowledge  Students cadefinitions independen marginal donotions such Students can street algorithms of Students can whether application. Students can whether application whether application. Students can whether application whether a	lus ete algebraic structur esitional logic  part successfully, stu  n explain the main of of modeling elemone ce assumptions) use stributions, density h as expected value n define decision pr ased on the chain rul caller, can be analyze t can describe the	definitions of pronents (randomed in discrete ar functions). Studies, variance, stroblems and expelle or Bayesian need in terms of no main ideas of s	s)  ned the follo  bability, and variables, nd continuous lents can deviated deviated deviated and and deviated and algorithetworks). Algorithetworks, algorith	wing learn d they car events, of us settings escribe cl ation, and orithms, o s bias of a rocesses	n give basi dependence s (joint an haracteristi d moments olving thes r estimator n estimator
Module Responsible  Admission Requirements  Recommended Previous Knowledge  Educational Objectives  Professional Competence  Knowledge  Knowledge  Knowledge  Students cadefinitions independen marginal donotions such Students can Students c	lus ete algebraic structur esitional logic  part successfully, stu  n explain the main of of modeling elemone ce assumptions) use stributions, density h as expected value n define decision pr ased on the chain rul caller, can be analyze t can describe the	Recitatio (small)  res (combinatoric udents have reacl ed in discrete ar functions). Studies, variance, stroblems and expulse or Bayesian neued in terms of no main ideas of states.	s)  ned the follo  bability, and variables, nd continuous ents can de andard devi blain algorith etworks). Alg tions such a stochastic p	wing learn d they car events, d us settings escribe cl ation, and nms for so orithms, o s bias of a rocesses	ing results n give basidependences (joint an haracteristid moments olving thes r estimator n estimato
Admission Requirements  Recommended Previous Knowledge  Educational Objectives  Professional Competence  Knowledge  Knowledge  Students cadefinitions independen marginal denotions such students can street algorithms students can students c	lus ete algebraic structur esitional logic  part successfully, stu  n explain the main of of modeling elemone ce assumptions) use stributions, density h as expected value n define decision pr ased on the chain rul caller, can be analyze t can describe the	definitions of property of the	s)  ned the follo  bability, and variables, nd continuous ents can de andard devi blain algorith etworks). Alg tions such a stochastic p	wing learn d they car events, of us settings escribe cl ation, and orithms, o s bias of a rocesses	ing results dependence s (joint an haracterist d moments olving thes r estimato n estimato
Admission Requirements  Recommended Previous Knowledge  Educational Objectives  Professional Competence  Knowledge  Knowledge  Students cadefinitions independen marginal denotions such students can street algorithms students can students c	lus ete algebraic structur esitional logic  part successfully, stu  n explain the main of of modeling elemone ce assumptions) use stributions, density h as expected value n define decision pr ased on the chain rul caller, can be analyze t can describe the	definitions of pronents (randomed in discrete ar functions). Studies, variance, stroblems and expelle or Bayesian need in terms of no main ideas of s	bability, and variables, and continuous dents can dendard deviolain algorithe tworks). Algorithes two such a stochastic p	d they car events, dus settings escribe cl ation, and onms for so orithms, o s bias of a rocesses	n give bas dependence s (joint an haracterist d moment olving thes r estimato n estimato
Recommended Previous Knowledge  Educational Objectives  Professional Competence  Students cadefinitions independen marginal donotions such students cast hey are etc. Students cadefinitions independent marginal donotions such students cast hey are etc. Students cadefinitions independent marginal donotions such students cadefinitions independent marginal donotions such students can	n explain the main of modeling elements of modeling elements assumptions) use stributions, density has expected value and define decision prased on the chain rul caller, can be analyzed to can describe the	definitions of pronents (randomed in discrete ar functions). Studies, variance, stroblems and expelle or Bayesian need in terms of no main ideas of s	bability, and variables, and continuous dents can dendard deviolain algorithe tworks). Algorithes two such a stochastic p	d they car events, dus settings escribe cl ation, and onms for so orithms, o s bias of a rocesses	n give bas dependence s (joint an haracterist d moment olving thes r estimato n estimato
Previous Knowledge	n explain the main of modeling elements of modeling elements assumptions) use stributions, density has expected value and define decision prased on the chain rul caller, can be analyzed to can describe the	definitions of pronents (randomed in discrete ar functions). Studies, variance, stroblems and expelle or Bayesian need in terms of no main ideas of s	bability, and variables, and continuous dents can dendard deviolain algorithe tworks). Algorithes two such a stochastic p	d they car events, dus settings escribe cl ation, and onms for so orithms, o s bias of a rocesses	n give bas dependence s (joint an haracterist d moment olving thes r estimato n estimato
Professional Competence  Students can definitions independent marginal donotions such the students can problems (but as they are etc. Students can algorithms and Students can students can be students can whether application i.e., students can whether application i.e., students can be s	n explain the main of modeling elemoner of modeling elemoner of modeling elemoner of modeling elemoner of modeling density in define decision properties on the chain rulus caller, can be analyzed to an describe the	definitions of pronents (random ed in discrete ar functions). Studies, variance, staroblems and expande or Bayesian need in terms of no main ideas of staroblems and expanded in terms of staroblems.	obability, and variables, and continuous dents can dendered deviation algorithe tworks). Algorithe tworks astochastic p	d they car events, dus settings escribe cl ation, and onms for so orithms, o s bias of a rocesses	n give bas dependence s (joint an haracterist d moment olving thes r estimato n estimato
Competence  Students can definitions independent marginal donotions such Students can problems (but as they are etc. Students can algorithms students can students can whether application.  Skills  Personal Competence  Social Competence  - Students can whether application.  Students can whether application.  - Students can whether application.	of modeling elemente assumptions) use stributions, density has expected value n define decision prased on the chain rulus caller, can be analyzed to can describe the	nents (random ed in discrete ar functions). Stud ues, variance, students and expule or Bayesian ned in terms of no main ideas of s	variables, nd continuou lents can d andard devi plain algorith etworks). Alg tions such a stochastic p	events, dus settings escribe clation, and on the contract of t	dependenc s (joint ar haracterist d moment olving thes r estimato n estimato
Students can definitions independent marginal donotions such Students can problems (but as they are etc. Students can algorithms students can students can students can whether application.  Personal Competence  Social Competence  - Students and own. They solving them  Autonomy - Students of own. They solving them	of modeling elemente assumptions) use stributions, density has expected value n define decision prased on the chain rulus caller, can be analyzed to can describe the	nents (random ed in discrete ar functions). Stud ues, variance, students and expule or Bayesian ned in terms of no main ideas of s	variables, nd continuou lents can d andard devi plain algorith etworks). Alg tions such a stochastic p	events, dus settings escribe clation, and on the contract of t	dependenc s (joint ar haracterist d moment olving thes r estimato n estimato
Skills whether applice, student reliable.  Personal Competence  - Students heterogene background exercise class own. They solving there  Autonomy - Students of the students o	Students can explain the main definitions of probability, and they can give basic definitions of modeling elements (random variables, events, dependence, independence assumptions) used in discrete and continuous settings (joint and marginal distributions, density functions). Students can describe characteristic notions such as expected values, variance, standard deviation, and moments. Students can define decision problems and explain algorithms for solving these problems (based on the chain rule or Bayesian networks). Algorithms, or estimators as they are caller, can be analyzed in terms of notions such as bias of an estimator, etc. Student can describe the main ideas of stochastic processes and explain algorithms for solving decision and computation problem for stochastic processes. Students can also explain basic statistical detection and estimation techniques.				
Competence  - Students heterogene background exercise classes own. They solving there are the students of the	Students can apply algorithms for solving decision problems, and they can justify whether approximation techniques are good enough in various application contexts i.e., students can derive estimators and judge whether they are applicable or				
- Students heterogene background exercise classes and sown. They solving there are a students of the solution					
own. They solving ther  Autonomy - Students of		ms (i.e., teams f	rom differen	t study pr	ograms ar
	re capable of checkin can specify open qu n.	•	-	•	•
- Students	an put their knowledo	ge in relation to t	he contents	of other le	ctures.
	have developed suff goal-oriented manne			le to wor	k for long
Workload in Hours Independen		udy Time in Lectu	re 56		
Credit points 6	t Study Time 124, Stu				
Course	t Study Time 124, Stu				
achievement Written exa	t Study Time 124, Stu				
Examination Written exa					

duration and scale	
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory Computer Science: Core qualification: Compulsory Data Science: Core qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory Computational Science and Engineering: Core qualification: Compulsory Computational Science and Engineering: Core qualification: Compulsory Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course LOZZZ, Cha	hastiss
Course L0777: Stoo	
	Lecture
Hrs/wk	2
СР	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Christian Seifert
Language	DE/EN
Cycle	SoSe
	Foundations of probability theory
	<ul> <li>Definitions of probability, conditional probability</li> <li>Random variables, dependencies, independence assumptions,</li> <li>Marginal and joint probabilities</li> <li>Distributions and density functions</li> <li>Characteristics: expected values, variance, standard deviation, moments</li> </ul>
Contont	Practical representations for joint probabilities  • Bayessche Netzwerke • Semantik, Entscheidungsprobleme, exakte und approximative Algorithmen  Stochastic processes
Content	<ul> <li>Stationarity, ergodicity</li> <li>Correlations</li> <li>Dynamic Bayesian networks, Hidden Markov networks, Kalman filters, queues</li> <li>Detection &amp; estimation</li> <li>Detectors</li> </ul>
	<ul> <li>Estimation rules and procedures</li> <li>Hypothesis and distribution tests</li> <li>Stochastic regression</li> </ul>
Literature	<ol> <li>Methoden der statistischen Inferenz, Likelihood und Bayes, Held, L., Spektrum 2008</li> <li>Stochastik für Informatiker, Dümbgen, L., Springer 2003</li> <li>Statistik: Der Weg zur Datenanalyse, Fahrmeir, L., Künstler R., Pigeot, I, Tutz, G., Springer 2010</li> <li>Stochastik, Georgii, HO., deGruyter, 2009</li> <li>Probability and Random Processes, Grimmett, G., Stirzaker, D., Oxford University Press, 2001</li> <li>Programmieren mit R, Ligges, U., Springer 2008</li> </ol>

Course L0778: Stochastics	
Тур	Recitation Section (small)
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Christian Seifert
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1181	L: Research Project Theoretical Mechanical Engineering		
Courses			
Title	Typ Hrs/wk CP		
Module Responsible	Dozenten des SD M		
Admission Requirements	None		
Recommended Previous Knowledge	<ul> <li>Finite-element-methods</li> <li>Control systems theory and design</li> <li>Applied dynamics</li> <li>Numerics of ordinary differential equations</li> </ul>		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
	The students are able to demonstrate their detailed knowledge in the field of theoretical mechanical engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society.  The students can develop solving strategies and approaches for fundamental and		
Knowledge	practical problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society.  Scientific work techniques that are used can be described and critically reviewed.		
Skills	The students are able to independently select methods for the project work and to justify this choice. They can explain how these methods relate to the field of worl and how the context of application has to be adjusted. General findings and furthe developments may essentially be outlined.		
Personal Competence			
Social Competence	The students are able to condense the relevance and the structure of the projec work, the work steps and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.		
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.		
	Independent Study Time 360, Study Time in Lecture 0		
Credit points			
Course achievement	None		
Examination	Study work		
Examination duration and scale	according to FSPO		
Assignment for the Following	Theoretical Mechanical Engineering: Core qualification: Compulsory		

Curricula

Module M1398	3: Selected Topics in Multibody Dynamics and Robotics
Course	
	Typ Hrs/wk CP - Mathematics and Mechanics in Autonomous Project-/problem- 2 6
Driving (L1981)	based Learning 2
Module Responsible	Prof. Robert Seifried
Admission Requirements	None
	Mechanics IV, Applied Dynamics or Robotics
Recommended Previous	Numerical Treatment of Ordinary Differential Equations
Knowledge 	Control Systems Theory and Design
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the module students demonstrate deeper knowledge and understanding in selected application areas of multibody dynamics and robotics
	Students are able
	+ to think holistically
Skills	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody systems
	+ to describe dynamics problems mathematically
	+ to implement dynamical problems on hardware
Personal Competence	
•	Students are able to
Social Competence	+ solve problems in heterogeneous groups and to document the corresponding results and present them
	Students are able to
Autonomy	+ assess their knowledge by means of exercises and projects.
Autonomy	+ acquaint themselves with the necessary knowledge to solve research oriented tasks.
<b>Workload in Hours</b>	Independent Study Time 152, Study Time in Lecture 28
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	TBA
the Following	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L1981: Formulas and Vehicles - Mathematics and Mechanics in Autonomous Driving		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	6	
<b>Workload in Hours</b>	Independent Study Time 152, Study Time in Lecture 28	
Lecturer	Prof. Robert Seifried	
Language	DE	
Cycle	WiSe	
Content		
	Seifried, R.: Dynamics of underactuated multibody systems, Springer, 2014	
Literature	Popp, K.; Schiehlen, W.: Ground vehicle dynamics, Springer, 2010	

## **Specialization Bio- and Medical Technology**

The specialization "biotechnology and medical technology" consists of modules for Intelligent Systems, Robotics and Navigation in medicine, supplemented by Endoprostheses and Materials and Regenerative Medicine, and completed by the modules Imaging Systems in medicine and Industrial Image Transformations in electives. Thus, the acquisition of knowledge and skills in engineering specific aspects of biotechnology and medical technology is at the heart of this specialization. In addition, subjects in the Technical Supplement Course for TMBMS (according FSPO) are freely selectable.

Module M1173	3: Applied Statis	tics			
Courses					
Title			Тур	Hrs/wk	СР
Applied Statistics (L15)	84)		Lecture	2	3
Applied Statistics (L15	86)		Project-/problem- based Learning	2	2
Applied Statistics (L15	85)		Recitation Section (small)	on 1	1
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge of stat	istical methods			
Educational Objectives	After taking part succes	ssfully, students h	ave reached the foll	owing learn	ning results
Professional Competence					
Knowledge	Students can explain the statistical methods and the conditions of their use.				
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results				
Personal Competence					
Social Competence	Team Work, joined pres	entation of result	S		
Autonomy	To understand and inter	rpret the questior	and solve		
Workload in Hours	Independent Study Time	e 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	Compulsor <b>₿onus</b> Yes None	<b>Form</b> Written elaborati	<b>Descrip</b> ion	tion	
Examination	Written exam				
Examination duration and scale	90 minutes, 28 question	าร			
Assignment for the Following Curricula	Mechanical Engineering Compulsory Mechatronics: Specialisa Mechatronics: Specialisa Biomedical Engineering Product Development, Compulsory	ation System Des ation Intelligent S : Core qualificatio	ign: Elective Compu ystems and Robotic n: Compulsory	lsory s: Elective (	Compulsory

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L1584: App	lied Statistics		
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Michael Morlock		
Language	DE/EN		
Cycle	WiSe		
	The goal is to introduce students to the basic statistical methods and their application to simple problems. The topics include:		
	Chi square test		
	Simple regression and correlation		
	Multiple regression and correlation		
Content	One way analysis of variance		
	Two way analysis of variance		
	Discriminant analysis		
	Analysis of categorial data		
	Chossing the appropriate statistical method		
	Determining critical sample sizes		
Literature	Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University, Lawrence L. Kupper University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University, Published by Duxbury Press, CB © 1998, ISBN/ISSN: 0-534-20910-6		

Course L1586: Applied Statistics		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Michael Morlock	
Language	DE/EN	
Cycle	WiSe	
Content	The students receive a problem task, which they have to solve in small groups $(n=5)$ . They do have to collect their own data and work with them. The results have to be presented in an executive summary at the end of the course.	
Literature	Selbst zu finden	

Course L1585: Applied Statistics		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Michael Morlock	
Language	DE/EN	
Cycle	WiSe	
Content	The different statistical tests are applied for the solution of realistic problems using actual data sets and the most common used commercial statistical software package (SPSS).	
Literature	Student Solutions Manual for Kleinbaum/Kupper/Muller/Nizam's Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University Lawrence L. Kupper University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University, Published by Duxbury Press, Paperbound © 1998, ISBN/ISSN: 0-534-20913-0	

Module M1334	4: BIO II: Biomaterials
Courses	
<b>Title</b> Biomaterials (L0593)	TypHrs/wkCPLecture23
Module Responsible	IPINI WUCHARI WOTOCK
Admission Requirements	INONE
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
-	The students can describe the materials of the human body and the materials bein used in medical engineering, and their fields of use.
Skills	The students can explain the advantages and disadvantages of different kinds of biomaterials.
Personal Competence	
Social Competence	The students are able to discuss issues related to materials being present or bein used for replacements with student mates and the teachers.
Autonomy	The students are able to acquire information on their own. They can also judge th information with respect to its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	INONE
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	

Course L0593: Biomaterials	
Тур	Lecture
Hrs/wk	2

Lecturer	Prof. Michael Morlock		
Language			
Cycle			
	Topics to be covered include:		
	Introduction (Importance, nomenclature, relations)		
	2. Biological materials		
	2.1 Basics (components, testing methods)		
	2.2 Bone (composition, development, properties, influencing factors)		
	<ol><li>Cartilage (composition, development, structure, properties, influencing factors)</li></ol>		
	2.4 Fluids (blood, synovial fluid)		
	3 Biological structures		
:	3.1 Menisci of the knee joint		
:	3.2 Intervertebral discs		
:	3.3 Teeth		
:	3.4 Ligaments		
	3.5 Tendons		
Content	3.6 Skin		
:	3.7 Nervs		
:	3.8 Muscles		
	4. Replacement materials		
	4.1 Basics (history, requirements, norms)		
	4.2 Steel (alloys, properties, reaction of the body)		
	4.3 Titan (alloys, properties, reaction of the body)		
	4.4 Ceramics and glas (properties, reaction of the body)		
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)		
	4.6 Natural replacement materials		
	Knowledge of composition, structure, properties, function and changes/adaptation of biological and technical materials (which are used for replacements in-vivo Acquisition of basics for theses work in the area of biomechanics.		
	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRo Press, 1984.		
ļ	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.		
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keel University, September 1978. New York: Wiley, 1998.		
	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchi		
ineranire	Livingstone, 1988.		

Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.

Module M0548	8: Bioelectromagnetics:	Principles and	d Applicatio	ns
Courses				
_	Principles and Applications (L0371) Principles and Applications (L0373)	<b>Typ</b> Lecture Recitation (small)	Hrs/wk 3 Section 2	<b>CP</b> 5
Module Responsible	Prof. Christian Schuster	(Smail)		
Admission Requirements	None			
	Basic principles of physics			
Educational Objectives	After taking part successfully, stud	dents have reached th	ne following learr	ing results
Professional Competence				
Knowledge	Students can explain the bas bioelectromagnetics, i.e. the quan in biological tissue. They can de phenomena and order them cor fields. They can give an overview characterization of electromagnet examples for therapeutic and d medical technology.	itification and application and exemplify responding to wavel over measurement attention fields in practical	tion of electroma the most import ength and frequ and numerical te applications . Th	gnetic fields ant physica ency of the chniques for ey can give
Skills	Students know how to apply varied electromagnetic fields in biological make use of the elementary soll assess the most important effect they can order the effects respectively, and they can analy develop validation strategies for effects of electromagnetic fields make an appropriate choice.	al tissue. In order to outions of Maxwell's is that these models corresponding to vize them in a quantity their predictions. The	do this they can r Equations. They predict for biolo vavelength and cative way. They ley are able to e	elate to and are able to gical tissue frequency are able to evaluate the
Personal Competence Social Competence	Students are able to work togeth are able to present their results			
Autonomy	Students are capable to gather publications and relate that inform to make a connection between to content of other lectures (e.g. the lectrical engineering / physics). The field of bioelectromagnetics in Engineering	nation to the context heir knowledge obta heory of electromag hey can communicat	of the lecture. T ined in this lectunetic fields, fund	hey are able ure with the amentals o
Workload in Hours	Independent Study Time 110, Stud	dy Time in Lecture 70	)	
	I			

Credit points	6			
Course achievement	CompulsorBonus Yes 10 %	<b>Form</b> Presentation	Description	
Examination	Oral exam			
Examination duration and scale	45 min			
the Following	Electromagnetic Compa Electrical Engineering: S International Managem Elective Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Compulsory Theoretical Mechanical Elective Compulsory	atibility: Elective Co Specialisation Medient and Engineering: Specialisation Art g: Specialisation Mediens: Specialisation Me		gineering:  Medicine:  Inistration:  It Theory:  Elective  Echnology:

Course L0371: Bioe	electromagnetics: Principles and Applications
Тур	Lecture
Hrs/wk	3
СР	
	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language	
Cycle	
	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)
	- Measurement techniques for characterization of electromagnetic fields
Content	- Behavior of electromagnetic fields of low frequency in biological tissue
333	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

Course L0373: Bioelectromagnetics: Principles and Applications				
Тур	Recitation Section (small)			
Hrs/wk	2			
СР	1			
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28			
Lecturer	Prof. Christian Schuster			
Language	DE/EN			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M092	1: Electronic Circuits for	Medical Applic	ations	
Courses				
<b>Title</b> Electronic Circuits for I	Medical Applications (L0696)	<b>Typ</b> Lecture Recitation S	Hrs/wk 2 ection 1	<b>CP</b> 3
	Medical Applications (L1056)  Medical Applications (L1408)	(small) Practical Course	1	2 1
Module Responsible	Prof Matthias Kuhl	Practical Course	1	1
Admission Requirements	None			
Recommended	Fundamentals of electrical engineer	ring		
Educational Objectives	After taking part successfully, stude	ents have reached the	following learn	ning results
Professional Competence				
Knowledge	<ul> <li>Students can explain the bas central nervous system</li> <li>Students are able to expla propagation along an axon</li> <li>Students can exemplify the devices</li> <li>Students can describe the spapplications</li> <li>Students can explain the functions</li> <li>Students are able to discuss and artificial eyes</li> </ul>	in the build-up of a communication between the communication between the communications of low-rections of prostheses, e	n action pote een neurons an noise amplifier e. g. an artificia	ntial and its nd electronic s for medical
Skills	<ul> <li>Students can calculate the potential</li> <li>Students can give scenarios power signal acquisition.</li> <li>Students can develop the ble</li> <li>Students can define the build eye.</li> </ul>	for further improven	nent of low-no	ise and low-
Personal Competence				
Social Competence	<ul> <li>Students are trained to solve teams together with experts</li> <li>Students are able to recognize for assistance to the right time.</li> <li>Students can document their results in a way that others contained.</li> </ul>	with different profess ze their specific limita ne. r work in a clear man	ional backgrou itions, so that ner and comm	nd. they can ask unicate their
	<ul> <li>Students are able to realistic define actions for improvements</li> <li>Students can break down</li> </ul>	ents when necessary.		

Autonomy	<ul> <li>schedule their work in a realistic way.</li> <li>Students can handle the complex data structures of bioelectrical experiments without needing support.</li> <li>Students are able to act in a responsible manner in all cases and situations of experimental work.</li> </ul>				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
	CompulsorBonus Form Description				
Course achievement	res None practical work				
	No None Excercises				
Examination	Written exam				
Examination duration and scale					
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory				

Course L0696: Elec	tronic Circuits for Medical Applications
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul> <li>Market for medical instruments</li> <li>Membrane potential, action potential, sodium-potassium pump</li> <li>Information transfer by the central nervous system</li> <li>Interface tissue - electrode</li> <li>Amplifiers for medical applications, analog-digital converters</li> <li>Examples for electronic implants</li> <li>Artificial eye, cochlea implant</li> </ul>
Literature	Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)  Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007  Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm  Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Course L1056: Electronic Circuits for Medical Applications				
Тур	Recitation Section (small)			
Hrs/wk	1			
СР	2			
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14			
Lecturer	Prof. Matthias Kuhl			
Language	EN			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

Course L1408: Elec	tronic Circuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul> <li>Market for medical instruments</li> <li>Membrane potential, action potential, sodium-potassium pump</li> <li>Information transfer by the central nervous system</li> <li>Interface tissue - electrode</li> <li>Amplifiers for medical applications, analog-digital converters</li> <li>Examples for electronic implants</li> <li>Artificial eye, cochlea implant</li> </ul>
Literature	Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks  Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010  Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009  Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)  Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007  Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm  Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

ourses							
itle				-	 Гур	Hrs/wk	СР
pplied Humanoid Rob	otics (L	.1794)		F	Project-/problem- pased Learning	6	6
Module Responsible	Patrick	< Göttsch					
Admission Requirements	None						
Recommended Previous Knowledge	•	Introduction	nted programi n to control sy tems theory a	stems	rithms and data st	ructures	
Educational Objectives	After t	aking part s	uccessfully, st	tudents ha	ve reached the fol	lowing learn	ing results
Professional Competence							
Knowledge	<ul> <li>Students can explain humanoid robots.</li> <li>Students can explain the basic concepts, relationships and methods of forward- and inverse kinematics</li> <li>Students learn to apply basic control concepts for different tasks in humanoic robotics.</li> </ul>						
Skills	•	C++, and u They are ca models if no They are c	se these mod apable of usin ecessary with apable of sel	els for robo g models i C++ code lecting me	r humanoid robotion to motion or other in Matlab for simulation on the real robot sthods for solving illable, and apply in	tasks. lation and t system. abstract p	esting thes
Personal Competence							
Social Competence		They can p		riate feedb	s in mixed teams a pack to others, and		
Autonomy		sources, an	d to put in into ndependently	o the conte	red information for ext of the lecture. sks and apply the	•	
orkload in Hours	Indepe	endent Stud	y Time 96, Stu	udy Time ir	Lecture 84		
Credit points	6						
Course achievement	None						
Examination	Writte	n elaboratio	n				
Examination duration and scale	5-10 p	pages					
					gence Engineering stems and Robotic		

Assignment for	Elective Compulsory
the Following	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
Curricula	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory

Course L1794: App	lied Humanoid Robotics
Тур	Project-/problem-based Learning
Hrs/wk	6
СР	6
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Patrick Göttsch
Language	DE/EN
Cycle	WiSe/SoSe
Content	<ul> <li>Fundamentals of kinematics</li> <li>Static and dynamic stability of humanoid robotic systems</li> <li>Combination of different software environments (Matlab, C++, etc.)</li> <li>Introduction to the necessary software frameworks</li> <li>Team project</li> <li>Presentation and Demonstration of intermediate and final results</li> </ul>
Literature	<ul> <li>B. Siciliano, O. Khatib. "Handbook of Robotics. Part A: Robotics Foundations", Springer (2008)</li> </ul>

Courses								
<b>Title</b> Medical Imaging Syste	ms (I 0:	819)			_	<b>yp</b> ecture	Hrs/wk	<b>CP</b>
Module			rass			ceure		
Admission								
Requirements Recommended Previous								
Knowledge Educational	After	takina n	art succes	eefully eti	udents have	e reached t	the following lear	nina results
Objectives Professional Competence	Aitei	Laking p	art succes	ssiully, ste		e reactieu (	e ronowing rear	
Knowledge	• • • • Descri	imagin Explair system Explair with th Name contra: Explair charac Explair ibe and ents are Explair	g systems how the s function and apply e fundame and desi sts; how spa terize the which im explain th able to:	system of system	components sical processical equation physical temporal reenerated; instruction relinical uses	s and the desses that mons; effects resolution conethods are of the differences and as	conents of the overall system of the overall system of the make imaging postequired to general and be influenced to general erent systems.	the imagir sible and us erate imag d and how te images;
Skills		mather o o	matical or Calculate or physica Determine and tempo Explain the clinical ap	physical of the parar I equation the influ oral resolu e importa plications	equations r meters of ir ns; lence of diff ution of ima ance of diff	equired; maging syste ferent syste aging syste erent imag	etems using the i	mathemation
Personal Competence								
Social Competence								
Autonomy	Stude		tand whic				nedical imaging; a measuring sy	stem can l
Workload in Hours	Indep	endent	Study Time	e 124, St	udy Time in	Lecture 5	6	
Credit points								
Course	None							
achievement	None							

Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Compulsory  Product Development Materials and Production: Specialisation Materials: Flective

Course L0819: Med	lical Imaging Systems
Тур	Lecture
Hrs/wk	4
СР	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dr. Michael Grass, Dr. Tim Nielsen, Dr. Sven Prevrhal, Frank Michael Weber
Language	DE
Cycle	SoSe
Content	
Literature	Primary book:  1. P. Suetens, "Fundamentals of Medical Imaging", Cambridge Press  Secondary books:  - A. Webb, "Introduction to Biomedical Imaging", IEEE Press 2003.  - W.R. Hendee and E.R. Ritenour, "Medical Imaging Physics", Wiley-Liss, New York, 2002.  - H. Morneburg (Edt), "Bildgebende Systeme für die medizinische Diagnostik", Erlangen: Siemens Publicis MCD Verlag, 1995.  - O. Dössel, "Bildgebende Verfahren in der Medizin", Springer Verlag Berlin, 2000.

Module M1335	5: BIO II: Artificial Joint	Replacement		
Courses				
<b>Title</b> Artificial Joint Replacer	ment (L1306)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.			
Educational Objectives	After taking part successfully, stud	dents have reached the t	following learn	ing results
Professional Competence	The students can have the differs	ent kinds of artificial limb	ns	
Knowledge Skills	The students can explain the advantages and disadvantages of different kinds of endoprotheses.			
Personal Competence				
Social Competence	The students are able to discuss i and the teachers.	ssues related to endopro	othese with stu	ıdent mates
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.			
<b>Workload in Hours</b>	Independent Study Time 62, Stud	y Time in Lecture 28		
Credit points	3			
Course achievement	None			
	Written exam			
Examination duration and scale				
the Following	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Orientierungsstudium: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L1306: Arti	ficial Joint Replacement
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
	Inhalt (deutsch)
	<ol> <li>EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes)</li> </ol>
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)
	3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate)
Content	4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten)
	5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren)
	6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz)
	7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
	8. DIE HAND (Anatomie, Biomechanik, Ge-lenkersatz)
	9. TRIBOLOGIE NATÜRLICHER UND KÜNST-LICHER GELENKE (Korrosion, Reibung, Verschleiß)
	Literatur:
	Kapandji, I: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.
Literature	Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994
Literature	Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febiger, Philadelphia, 1989.
	Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.
	Sobotta und Netter für Anatomie der Gelenke

Module M0630: Robotics and Navigation in Medicine					
Courses					
Title			Тур	Hrs/wk	СР
	on in Medicine (L0335)		Lecture	2	3
Robotics and Navigation			Project Seminar	2	2
Robotics and Navigation	on in Medicine (L0336)		Recitation Se (small)	ction 1	1
Module Responsible	Prof. Alexander Schla	efer			
Admission Requirements					
Recommended Previous Knowledge	<ul> <li>principles of presented</li> </ul>	ath (algebra, analys ogramming, e.g., in ab skills			
Educational Objectives		essfully, students h	ave reached the f	following learn	ing results
Professional					
Competence	;				
Knowledge	The students can exp illustrate systems and respect to collision of typical systems regard	d their components detection and saf	s in detail. Syster ety and regulation	ns can be eva	aluated with
Skills	The students are able to design and evaluate navigation systems and robotic systems for medical applications.				
Personal Competence					
Social Competence	The students discuss incoorporate feedback		r groups, provide	helpful feedb	ack and car
Autonomy	The students can refl They can present the			the results o	f their work
Workload in Hours	Independent Study Ti	me 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	I Voc 10 %	<b>Form</b> Written elaborati Presentation		ription	
Examination	Written exam				
Examination duration and scale	90 minutes				
	Computer Science: Sp Electrical Engineering International Manager Elective Compulsory International Manage and Biotechnology: El Mechatronics: Special Biomedical Engineerin Elective Compulsory Biomedical Engineer	: Specialisation Medment and Engineering ment and Engineer ective Compulsory isation Intelligent Song: Specialisation A	dical Technology: ng: Specialisation ring: Specialisation ystems and Robo rtificial Organs ar	Elective Composite II. Electrical II. Electrical II. Process tics: Elective Cond Regenerative	oulsory Engineering Engineering Compulsory ve Medicine

	Compulsory
Assignment for	Biomedical Engineering: Specialisation Medical Technology and Control Theory:
the Following	Elective Compulsory
Curricula	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	Product Development, Materials and Production: Specialisation Product
	Development: Elective Compulsory
	Product Development, Materials and Production: Specialisation Production: Elective
	Compulsory
	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology:
	Elective Compulsory

Course L0335: Robotics and Navigation in Medicine		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	SoSe	
Content	<ul> <li>kinematics</li> <li>calibration</li> <li>tracking systems</li> <li>navigation and image guidance</li> <li>motion compensation</li> <li>The seminar extends and complements the contents of the lecture with respect to recent research results.</li> </ul>	
Literature	Spong et al.: Robot Modeling and Control, 2005 Troccaz: Medical Robotics, 2012 Further literature will be given in the lecture.	

Course L0338: Robotics and Navigation in Medicine		
Тур	Project Seminar	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0336: Rob	Course L0336: Robotics and Navigation in Medicine		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	1		
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Alexander Schlaefer		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

	2: Technical Elective Course for TMBMS (according to fic Regulations)
Courses	
Title	Typ Hrs/wk CP
Module Responsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
	see FSPO
Personal Competence	
Social Competence	see FSPO
Autonomy	
<b>Workload in Hours</b>	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Module M1249	9: Medical Imaging			
Courses				
<b>Title</b> Medical Imaging (L169 Medical Imaging (L169		<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3 3
Module Responsible	Prof. Tobias Knopp			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully,	students have reached t	he following learn	ing results
Professional Competence Knowledge				
Skills Personal Competence				
Social Competence Autonomy				
<b>Workload in Hours</b>	Independent Study Time 124, S	Study Time in Lecture 56	5	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Computer Science: Specialisati Computer Science: Specialisati Electrical Engineering: Speciali Electrical Engineering: Speciali Theoretical Mechanical Engine Elective Compulsory Theoretical Mechanical Engin Compulsory	on II: Intelligence Engine sation Medical Technolo sation Medical Technolo eering: Specialisation B	eering: Elective Cogy: Elective Compgy: Elective Compgy: Elective Compgio- and Medical	ompulsory oulsory oulsory Technology:

Course L1694: Medical Imaging		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Tobias Knopp	
Language	DE	
Cycle	WiSe	
Content		
	Bildgebende Verfahren in der Medizin; O. Dössel; Springer, Berlin, 2000	
	<b>Bildgebende Systeme für die medizinische Diagnostik</b> ; H. Morneburg (Hrsg.); Publicis MCD, München, 1995	
Literature	Introduction to the Mathematics of Medical Imaging; C. L.Epstein; Siam, Philadelphia, 2008	
	<b>Medical Image Processing, Reconstruction and Restoration</b> ; J. Jan; Taylor and Francis, Boca Raton, 2006	
	<b>Principles of Magnetic Resonance Imaging</b> ; ZP. Liang and P. C. Lauterbur; IEEE Press, New York, 1999	

Course L1695: Medical Imaging		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Tobias Knopp	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0746	6: Microsystem	Engineering	ı		
Courses					
Title Microsystem Engineeri	_		<b>Typ</b> Lecture Project-/problem-	Hrs/wk	<b>CP</b> 4
Microsystem Engineeri	ng (L0682)		based Learning	2	2
	!				
Admission Requirements	INODE				
Recommended Previous Knowledge	Basic courses in physic	cs, mathematics a	and electric enginee	ring	
Educational Objectives	LATTER TAKING NATT SIICCE	essfully, students	have reached the fo	ollowing learn	ing results
Professional Competence		out the most impe	ortant tachnologies	and materials	c of MEMS a
Knowledge	The students know about the students know about the students know about the students will be students as the students will be students will be students as the students will be stu	ns in sensors and	actuators.		
	Students are able to components and to eva				ur of MEMS
Personal Competence		olve specific prob	olems alone or in a	group and to	present the
Social Competence	results accordingly.			3 ap	<b>P</b> • • • • • • • • • • • • • • • • • • •
Autonomy	Students are able to acquire particular knowledge using specialized literature and to integrate and associate this knowledge with other fields.				
Workload in Hours	Independent Study Tim	ne 124, Study Tim	ne in Lecture 56		
Credit points	i				
achievement		<b>Form</b> Presentation	Descr	iption	
Examination Examination duration and scale	2h				
Assignment for the Following Curricula	Biomedical Engineering	nent and Enginee nent and Enginee ng and Managen sation System De g: Specialisation	ring: Specialisation ring: Specialisation ment: Specialisation sign: Elective Comp Artificial Organs and	II. Mechatron  Mechatron  Julsory  Regenerativ	nics: Elective

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L0680: Microsystem Engineering		
Тур	Lecture	
Hrs/wk	2	
СР		
	Independent Study Time 92, Study Time in Lecture 28	
	Prof. Manfred Kasper	
Language		
Cycle		
	Object and goal of MEMS	
	Scaling Rules	
	Lithography	
	Film deposition	
	Structuring and etching	
	Energy conversion and force generation	
	Electromagnetic Actuators	
	Reluctance motors	
Content	Piezoelectric actuators, bi-metal-actuator	
	Transducer principles	
	Signal detection and signal processing	
	Mechanical and physical sensors	
	Acceleration sensor, pressure sensor	
	Sensor arrays	
	System integration	
	Yield, test and reliability	
	M. Kasper: Mikrosystementwurf, Springer (2000)	
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press (1997)	
l		

Course L0682: Microsystem Engineering		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Manfred Kasper	
Language	EN	
Cycle	WiSe	
	Examples of MEMS components	
Content	Layout consideration	
	Electric, thermal and mechanical behaviour	
	Design aspects	
Literature	Wird in der Veranstaltung bekannt gegeben	

Module M0623	3: Intelligent	t Syst	tems in Me	dicine		
Courses						
Title				Тур	Hrs/wk	СР
Intelligent Systems in				Lecture	2	3
Intelligent Systems in	Medicine (L0334)			Project Seminar Recitation S	2 ection <sub>1</sub>	2
Intelligent Systems in	Medicine (L0333)			(small)	1	1
Module Responsible	I Prof. Alexander S	chlaefe	r			
Admission Requirements	None					
Recommended Previous Knowledge	• principles o	of stoch of progr	ramming, Java/C-		)	
Educational Objectives	After taking part	success	sfully, students h	ave reached the	following learr	ning results
Professional Competence						
Knowledge	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.					
Skills	The students can regression, and p data and evaluate	predicti	on. They can as	sess the metho		
Personal Competence	The students disc			groups, provid	e helpful feedb	ack and can
Autonomy	The students car They can present				t the results o	f their work
Workload in Hours	Independent Stud	ly Time	110, Study Time	e in Lecture 70		
Credit points	6					
Course achievement	I Yes 10 %		<b>Form</b> Presentation Written elaborati		cription	
Examination	Written exam					
Examination duration and scale	90 minutes					
Assignment for	Computer Science Electrical Enginee Mechatronics: Spe Biomedical Engin Elective Compulse Biomedical Engin Compulsory	ering: S ecialisa eering: ory	pecialisation Med tion Intelligent S Specialisation A	dical Technology ystems and Rob rtificial Organs a	: Elective Compotics: Elective (and Regenerative)	oulsory Compulsory ve Medicine:

the Following	Biomedical Engineering: Specialisation Medical Technology and Control Theory:
Curricula	Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology:
	Elective Compulsory

Course L0331: Intelligent Systems in Medicine		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>methods for search, optimization, planning, classification, regression and prediction in a clinical context</li> <li>representation of medical knowledge</li> <li>understanding challenges due to clinical and patient related data and data acquisition</li> <li>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</li> </ul>	
Literature	Russel & Norvig: Artificial Intelligence: a Modern Approach, 2012 Berner: Clinical Decision Support Systems: Theory and Practice, 2007 Greenes: Clinical Decision Support: The Road Ahead, 2007 Further literature will be given in the lecture	

Course L0334: Intelligent Systems in Medicine		
Тур	Project Seminar	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0333: Intelligent Systems in Medicine	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

## **Specialization Energy Systems**

The focus of the specialization "energy technology" lies on the acquisition of knowledge and skills on an economically and ecologically sensible provision of electricity, heating and coooling on the basis of conventional and renewable energy systems. This is made possible by modules in the areas of fluid mechanics and ocean energy, solar energy, electric energy, heating technology, air conditioners, power plants, steam and Cogeneration and combustion technology electives. In addition, subjects in the Technical Supplement Course for TMBMS (according FSPO) are freely selectable.

Module M123! Power System	5: Electrical Power Systems	i: Intro	duction to E	lectrical
Courses				
Title		Тур	Hrs/wk	СР
	ms I: Introduction to Electrical Power Systems		3	4
Electrical Power System (L1671)	ms I: Introduction to Electrical Power Systems	Recitation (large)	Section 2	2
Module Responsible	Prof. Christian Becker			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Electrical Engineering			
Educational Objectives	After taking part successfully, students h	ave reached	the following learn	ing results
Professional Competence				
Knowledge	Students are able to give an overview of conventional and modern electric power systems. They can explain in detail and critically evaluate technologies of electric power generation, transmission, storage, and distribution as well as integration or equipment into electric power systems.			
Skills	With completion of this module the students are able to apply the acquired skills in applications of the design, integration, development of electric power systems and to assess the results.			
Personal Competence				
Social Competence	The students can participate in spec advance ideas and represent their own w			discussions
Autonomy	Students can independently tap knowled	ge of the emp	phasis of the lectu	res.
<b>Workload in Hours</b>	Independent Study Time 110, Study Time	e in Lecture 7	0	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 - 150 minutes			
	General Engineering Science (German	n program,	7 semester): S	pecialisation

the Following	Electrical Engineering: Elective Compulsory Data Science: Core qualification: Elective Compulsory Electrical Engineering: Core qualification: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory Renewable Energies: Core qualification: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory
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Course L1670: Elec	trical Power Systems I: Introduction to Electrical Power Systems
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	<ul> <li>fundamentals and current development trends in electric power engineering</li> <li>tasks and history of electric power systems</li> <li>symmetric three-phase systems</li> <li>fundamentals and modelling of eletric power systems         <ul> <li>lines</li> <li>transformers</li> <li>synchronous machines</li> <li>induction machines</li> <li>loads and compensation</li> <li>grid structures and substations</li> </ul> </li> <li>fundamentals of energy conversion         <ul> <li>electro-mechanical energy conversion</li> <li>thermodynamics</li> <li>power station technology</li> <li>renewable energy conversion systems</li> </ul> </li> <li>steady-state network calculation         <ul> <li>network modelling</li> <li>load flow calculation</li> <li>(n-1)-criterion</li> </ul> </li> <li>symmetric failure calculations, short-circuit power</li> <li>control in networks and power stations</li> <li>grid protection</li> <li>grid planning</li> <li>power economy fundamentals</li> </ul>
Literature	<ul> <li>K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013</li> <li>A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017</li> <li>R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008</li> </ul>

Course L1671: Elec	trical Power Systems I: Introduction to Electrical Power Systems
Тур	Recitation Section (large)
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	<ul> <li>fundamentals and current development trends in electric power engineering</li> <li>tasks and history of electric power systems</li> <li>symmetric three-phase systems</li> <li>fundamentals and modelling of eletric power systems         <ul> <li>lines</li> <li>transformers</li> <li>synchronous machines</li> <li>induction machines</li> <li>loads and compensation</li> <li>grid structures and substations</li> </ul> </li> <li>fundamentals of energy conversion         <ul> <li>electro-mechanical energy conversion</li> <li>thermodynamics</li> <li>power station technology</li> <li>renewable energy conversion systems</li> </ul> </li> <li>steady-state network calculation         <ul> <li>network modelling</li> <li>load flow calculation</li> <li>(n-1)-criterion</li> </ul> </li> <li>symmetric failure calculations, short-circuit power</li> <li>control in networks and power stations</li> <li>grid protection</li> <li>grid planning</li> <li>power economy fundamentals</li> </ul>
Literature	<ul> <li>K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013</li> <li>A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017</li> <li>R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008</li> </ul>

Module M0742	2: Thermal Energy Systems			
Courses				
Title		Тур	Hrs/wk	СР
Thermal Engergy Syste	ems (L0023)	Lecture	3	5
Thermal Engergy Syste	ems (L0024)	Recitation (large)	Section 1	1
Module Responsible	Prof. Gerhard Schmitz			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dy	namics, Heat∃	Fransfer	
Educational Objectives	After taking part successfully, students h	nave reached t	he following learn	ing results
Professional Competence				
Knowledge	Students know the different energy con efficiency and annual efficiency. They had transfer, especially in regard to buildings with German energy saving code and or differ different heating systems in the control such heating systems. They are a transient temperatures in a furnace. The formations in the flames of small burne the atmosphere. They are able to moriented languages.  Students are able to calculate the heating to choose the suitable components. The and have the ability to perform simple poan write Modelica programs and can they are able to perform scientific work.	ave increased as and mobile as ther technical domestic and able to model and how to able to the model thermodel thermodel thermodel thermodel thermodel thermodel to are able to lanning tasks, transfer resea	knowledge in head applications. They relevant rules. They is a furnace and to complete the fluor conduct the fluor systems different heating calculate a pipel regarding solar earch knowledge in	at and mass are familian ney know to and how to alculate the of emission e gases into with object systems and ine network energy. They
Personal Competence Social Competence	The students are able to discuss in small	groups and d	evelop an approac	ch.
Autonomy	Students are able to define independ existing knowledge as well as to find way			
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56	5	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
	Bioprocess Engineering: Specialisation A Compulsory Energy and Environmental Engineering: Compulsory			

Assignment for the Following	Energy Systems: Specialisation Energy Systems: Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory
Curricula	Product Development, Materials and Production: Core qualification: Elective
	Compulsory
	Renewable Energies: Core qualification: Compulsory
	Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0023: Thermal Engergy Systems		
Тур	Lecture	
Hrs/wk	3	
СР	5	
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42	
Lecturer	Prof. Gerhard Schmitz	
Language	DE	
Cycle	WiSe	
	1. Introduction	
	2. Fundamentals of Thermal Engineering 2.1 Heat Conduction 2.2 Convection 2.3 Radiation 2.4 Heat transition 2.5 Combustion parameters 2.6 Electrical heating 2.7 Water vapor transport	
Content	3. Heating Systems 3.1 Warm water heating systems 3.2 Warm water supply 3.3 piping calculation 3.4 boilers, heat pumps, solar collectors 3.5 Air heating systems 3.6 radiative heating systems	
	4. Thermal traetment systems 4.1 Industrial furnaces 4.2 Melting furnaces 4.3 Drying plants 4.4 Emission control 4.5 Chimney calculation 4.6 Energy measuring	
	5. Laws and standards 5.1 Buildings 5.2 Industrial plants	
Literature	<ul> <li>Schmitz, G.: Klimaanlagen, Skript zur Vorlesung</li> <li>VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013</li> <li>Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009</li> <li>Recknagel, H.; Sprenger, E.; Schrammek, ER.: Taschenbuch für Heizungund Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013</li> </ul>	

Course L0024: Thermal Engergy Systems		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Gerhard Schmitz	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

## Module M1037: Steam Turbines in Energy, Environmental and Power Train Engineering

Courses				_
Title	ann anda an antal a 15 T	Тур	Hrs/wk	СР
Steam turbines in energy, environmental and Power Train Engineering (L1286)		Lecture	3	5
	rgy, environmental and Power Train	Recitation (small)	Section 1	1
Module Responsible	I Prof. Altons Karner			
Admission Requirements	LNIONA			
Recommended Previous Knowledge	"Technical Thermodynamics I     "Fluid Mochanics"			
Educational Objectives	I ATTOR TAKING NART CHICCOCCTIIIIV CTHOOR	nts have reached	the following learr	ing results
Professional Competence				
Knowledge	After successful completion of the m     name and identify the varieturbines     describe and explain the key of turbines     classify different construction according to size and operating describe the thermodynamic	ous parts and coperating condition types and differences and the che latter a turbine stage are the operating aspects and devenstruction characterist	onstructive group ons for the applicate entiate among ste e constructive and ad a stage assemb ons of the turbine range and the elop from the the eristics cics of different tur	os of steam cion of steam am turbines of steam am turbines of steam am turbines of constructive of the con
Skills	In the module the students learn the design and operational evaluation confidence in seeking optimisations.  • obtain the ability to analyse to be utilised thermodynamically viewpoints  • can evaluate the performant energy sources, for supplying electricity grid  • on the basis of the impact components, can describe prevention  • can describe the key require Thermal Power Plants, based legislative frameworks.	n of complex p They specifically: he potential of vally, from the ener ce and technical base load and b of power plant the precaution	ant, and gain in a serious energy sour a serious energy sour a serious in usual ancing reserve properation on the sary principles of the serious anagement and the serious energians.	n particular ces that can dechnical sing various bower to the integrity of for damage d Design of

Personal Competence Social Competence	In the module the students learn:  • to work together with others whilst seeking a solution • to assist each other in problem solving • to conduct discussions • to present work results • to work respectfully within the team.
Autonomy	In the module the students learn the independent working of a complex theme whilst considering various aspects. They also learn how to combine independent functions in a system.  The students become the ability to gain independently knowledge and transfer it also to new problem solving.
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L1286: Stea	am turbines in energy, environmental and Power Train Engineering
	Lecture
Hrs/wk	
СР	
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
	Dr. Christian Scharfetter
Language	DE
Cycle	WiSe
Content	<ul> <li>Introduction</li> <li>Construction Aspects of a Steam Turbine</li> <li>Energy Conversion in a Steam Turbine</li> <li>Construction Types of Steam Turbines</li> <li>Behaviour of Steam Turbines</li> <li>Sealing Systems for Steam Turbines</li> <li>Axial Thrust</li> <li>Regulation of Steam Turbines</li> <li>Stiffness Calculation of the Blades</li> <li>Blade and Rotor Oscillations</li> <li>Fundamentals of a Safe Steam Turbine Operation</li> <li>Application in Conventional and Renewable Power Stations</li> <li>Connection to thermal and electrical energy networks, interfaces</li> <li>Conventional and regenerative power plant concepts, drive technology</li> <li>Analysis of the global energy supply market</li> <li>Applications in conventional and regenerative power plants</li> <li>Different power plant concepts and their influence on the steam turbine (engine and gas turbine power plants with waste heat utilization, geothermal energy, solar thermal energy, biomass, biogas, waste incineration).</li> <li>Classic combined heat and power generation as a combined product of the manufacturing industry</li> <li>Impact of change in the energy market, operating profiles</li> <li>Applications in drive technology</li> <li>Operating and maintenance concepts</li> <li>The lecture will be deepened by means of examples, tasks and two excursions</li> </ul>
Literature	<ul> <li>Traupel, W.: Thermische Turbomaschinen. Berlin u. a., Springer (TUB HH: Signatur MSI-105)</li> <li>Menny, K.: Strömungsmaschinen: hydraulische und thermische Kraft- und Arbeitsmaschinen. Ausgabe: 5. Wiesbaden, Teubner, 2006 (TUB HH: Signatur MSI-121)</li> <li>Bohl, W.: Aufbau und Wirkungsweise. Ausgabe 6. Würzburg, Vogel, 1994 (TUB HH: Signatur MSI-109)</li> <li>Bohl, W.: Berechnung und Konstruktion. Ausgabe 6. Aufl. Würzburg, Vogel, 1999 (TUB HH: Signatur MSI-110)</li> </ul>

Course L1287: Steam turbines in energy, environmental and Power Train Engineering		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Christian Scharfetter	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

	2: Technical Elective Course for TMBMS (according to fic Regulations)
Courses	
Title	Typ Hrs/wk CP
Kesponsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	see FSPO
Skills	see FSPO
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Module M0512	2: Use of Solar Energy			
Courses				
Title		Тур	Hrs/wk	СР
Energy Meteorology (L	0016)	Lecture Recitation	1 Section	1
Energy Meteorology (L	0017)	(small)	Section 1	1
Collector Technology ( Solar Power Generation		Lecture Lecture	2 2	2 2
		Lecture	2	2
Responsible	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended				
Previous Knowledge	none			
Educational Objectives	After taking part successfully, stud	dents have reached th	ne following learr	ning results
Professional Competence				
Knowledge	With the completion of this mod foundations and current issues an and evaulate these critically in c subject specific issues. In particul within a solar cell and explain the Furthermore, they can provide a thermal systems.	d problems in the fiel- consideration of the parthey can profession e specific features of	d of solar energy prior curriculum mally describe the application of so	and explain and current ne processes lar modules.
Skills	Students can apply the acquire systems using solar radiation. In evaluate potential and constraints geographical assumptions. They consideration of technical asp comprehensive knowledge stude conditions of these systems. The radiation theory for these topics.	this context, for ex of solar energy system are able to dimensi ects and given as ents can evalute t	ample they can ems with respec on solar energy ssumptions. Usi he economic a	assess and todifferent systems in ng module- and ecologic
Personal Competence				
Social Competence	Students are able to discuss issue sector addressed within the modu		elds in the renev	vable energy
Autonomy	Students can independently explanation about the subject area with respet the assistance of lecturers, they cand dimensioning solar energy concrete assess their specific learn workflow.	ect to emphasis fo the can discrete use calcu systems. Based or	e lectures. Furth llation methods n this procedur	ermore, with for analysing re they can
Workload in Hours	Independent Study Time 96, Study	y Time in Lecture 84		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination				

scale	
Assignment for the Following Curricula	Ponowable Engraies: Core qualification: Compulsory

Course L0016: Ene	rgy Meteorology
Тур	Lecture
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Volker Matthias, Dr. Beate Geyer
Language	DE
Cycle	SoSe
Content	<ul> <li>Introduction: radiation source Sun, Astronomical Foundations, Fundamentals of radiation</li> <li>Structure of the atmosphere</li> <li>Properties and laws of radiation         <ul> <li>Polarization</li> <li>Radiation quantities</li> <li>Planck's radiation law</li> <li>Wien's displacement law</li> <li>Stefan-Boltzmann law</li> <li>Kirchhoff's law</li> <li>Brightness temperature</li> <li>Absorption, reflection, transmission</li> </ul> </li> <li>Radiation balance, global radiation, energy balance</li> <li>Atmospheric extinction</li> <li>Mie and Rayleigh scattering</li> <li>Radiative transfer</li> <li>Optical effects in the atmosphere</li> <li>Calculation of the sun and calculate radiation on inclined surfaces</li> </ul>
Literature	<ul> <li>Helmut Kraus: Die Atmosphäre der Erde</li> <li>Hans Häckel: Meteorologie</li> <li>Grant W. Petty: A First Course in Atmosheric Radiation</li> <li>Martin Kaltschmitt, Wolfgang Streicher, Andreas Wiese: Renewable Energy</li> <li>Alexander Löw, Volker Matthias: Skript Optik Strahlung Fernerkundung</li> </ul>

Course L0017: Energy Meteorology		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Beate Geyer	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0018: Coll	octor Tochnology
	Lecture
Hrs/wk	
CP	
	Independent Study Time 32, Study Time in Lecture 28
	Prof. Agis Papadopoulos
Language	
Cycle	
Content	<ul> <li>Introduction: Energy demand and application of solar energy.</li> <li>Heat transfer in the solar thermal energy: conduction, convection, radiation.</li> <li>Collectors: Types, structure, efficiency, dimensioning, concentrated systems.</li> <li>Energy storage: Requirements, types.</li> <li>Passive solar energy: components and systems.</li> <li>Solar thermal low temperature systems: collector variants, construction, calculation.</li> <li>Solar thermal high temperature systems: Classification of solar power plants construction.</li> <li>Solar air conditioning.</li> </ul>
Literature	<ul> <li>Vorlesungsskript.</li> <li>Kaltschmitt, Streicher und Wiese (Hrsg.). Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, 5. Auflage, Springer, 2013.</li> <li>Stieglitz und Heinzel .Thermische Solarenergie: Grundlagen, Technologie, Anwendungen. Springer, 2012.</li> <li>Von Böckh und Wetzel. Wärmeübertragung: Grundlagen und Praxis, Springer, 2011.</li> <li>Baehr und Stephan. Wärme- und Stoffübertragung. Springer, 2009.</li> <li>de Vos. Thermodynamics of solar energy conversion. Wiley-VCH, 2008.</li> <li>Mohr, Svoboda und Unger. Praxis solarthermischer Kraftwerke. Springer, 1999.</li> </ul>

Course L0015: Sola	r Power Generation			
Тур	Lecture			
Hrs/wk				
СР	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Alf Mews, Martin Schlecht, Roman Fritsches			
Language	DE			
Cycle				
Content	<ol> <li>Introduction</li> <li>Primary energy and consumption, available solar energy</li> <li>Physics of the ideal solar cell</li> <li>Light absorption PN junction characteristic values of the solar cell efficiency</li> <li>Physics of the real solar cell</li> <li>Charge carrier recombination characteristics, junction layer recombination, equivalent circuit</li> <li>Increasing the efficiency</li> <li>Methods for increasing the quantum yield, and reduction of recombination</li> <li>Straight and tandem structures</li> <li>Hetero-junction, Schottky, electrochemical, MIS and SIS-cell tandem cell</li> <li>Concentrator</li> <li>Concentrator optics and tracking systems</li> <li>Technology and properties: types of solar cells, manufacture, single crystal silicon and gallium arsenide, polycrystalline silicon, and silicon thin film cells, thin-film cells on carriers (amorphous silicon, CIS, electrochemical cells)</li> <li>Modules</li> <li>Circuits</li> </ol>			
Literature	<ul> <li>A. Götzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik, Teubner Studienskripten, Stuttgart, 1995</li> <li>A. Götzberger: Sonnenenergie: Photovoltaik: Physik und Technologie der Solarzelle, Teubner Stuttgart, 1994</li> <li>HJ. Lewerenz, H. Jungblut: Photovoltaik, Springer, Berlin, Heidelberg, New York, 1995</li> <li>A. Götzberger: Photovoltaic solar energy generation, Springer, Berlin, 2005</li> <li>C. Hu, R. M. White: Solar Cells, Mc Graw Hill, New York, 1983</li> <li>HG. Wagemann: Grundlagen der photovoltaischen Energiewandlung: Solarstrahlung, Halbleitereigenschaften und Solarzellenkonzepte, Teubner, Stuttgart, 1994</li> <li>R. J. van Overstraeten, R.P. Mertens: Physics, technology and use of photovoltaics, Adam Hilger Ltd, Bristol and Boston, 1986</li> <li>B. O. Seraphin: Solar energy conversion Topics of applied physics V 01 31, Springer, Berlin, Heidelberg, New York, 1995</li> <li>P. Würfel: Physics of Solar cells, Principles and new concepts, Wiley-VCH, Weinheim 2005</li> <li>U. Rindelhardt: Photovoltaische Stromversorgung, Teubner-Reihe Umwelt, Stuttgart 2001</li> <li>V. Quaschning: Regenerative Energiesysteme, Hanser, München, 2003</li> <li>G. Schmitz: Regenerative Energien, Ringvorlesung TU Hamburg-Harburg 1994/95, Institut für Energietechnik</li> </ul>			

Module M0721	L: Air Conditioning			
Courses				
Title		Тур	Hrs/wk	СР
Air Conditioning (L059	4)	Lecture	3	5
Air Conditioning (L059	5)	Recitation (large)	Section 1	1
Module Responsible	Prof. Gerhard Schmitz			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid	Dynamics, Heat	Transfer	
Educational Objectives	After taking part successfully, studen	ts have reached	the following lear	ning results
Professional				
Competence				
Knowledge	Students know the different kinds of air conditioning systems for buildings and mobile applications and how these systems are controlled. They are familiar with the change of state of humid air and are able to draw the state changes in a h1+x,x diagram. They are able to calculate the minimum airflow needed for hygienic conditions in rooms and can choose suitable filters. They know the basic flow pattern in rooms and are able to calculate the air velocity in rooms with the help of simple methods. They know the principles to calculate an air duct network. They know the different possibilities to produce cold and are able to draw these processes into suitable thermodynamic diagrams. They know the criteria for the assessment of refrigerants.			
Skills	Students are able to configure air applications. They are able to calcul perform simple planning tasks, regar can transfer research knowledge intwork in the field of air conditioning.	ate an air duct n ding natural hea	etwork and have t sources and hea	the ability to at sinks. They
Personal Competence Social Competence	The students are able to discuss in sr	nall groups and o	develop an approa	ach.
Autonomy	Students are able to define indepo existing knowledge as well as to find			
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 5	66	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and				

scale	
the Following	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0594: Air Conditioning				
Тур	Lecture			
Hrs/wk	3			
СР				
	Independent Study Time 108, Study Time in Lecture 42			
Lecturer Language	Prof. Gerhard Schmitz			
Cycle				
	1. Overview			
	1.1 Kinds of air conditioning systems			
	1.2 Ventilating			
	1.3 Function of an air condition system			
	2. Thermodynamic processes			
	2.1 Psychrometric chart			
	2.2 Mixer preheater, heater			
	2.3 Cooler			
	2.4 Humidifier			
	2.5 Air conditioning process in a Psychrometric chart			
	2.6 Desiccant assisted air conditioning			
	3. Calculation of heating and cooling loads			
Content	3.1 Heating loads			
	3.2 Cooling loads			
	3.3 Calculation of inner cooling load			
	3.4 Calculation of outer cooling load			
	4. Ventilating systems			
	4.1 Fresh air demand			
	4.2 Air flow in rooms			
	4.3 Calculation of duct systems			
	[101]			

	4.4 Fans	
4.5 Filters		
	5. Refrigeration systems	
	5.1. compression chillers	
	5.2Absorption chillers	
Literature	<ul> <li>Schmitz, G.: Klimaanlagen, Skript zur Vorlesung</li> <li>VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013</li> <li>Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009</li> <li>Recknagel, H.; Sprenger, E.; Schrammek, ER.: Taschenbuch für Heizungund Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013</li> </ul>	

Course L0595: Air Conditioning			
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	1		
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Gerhard Schmitz		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses								
Title Lagrangian transport in turbulent flows (L2301)				<b>Typ</b> Lecture		Hrs/wk	<b>CP</b> 3	
Computational Fluid Dy	/namics	s - Exercises	s in OpenFo	am (L1375)	Recitation (small)	Section	1	1
Computational Fluid Dy	/namics	s in Process	Engineering	g (L1052)	Lecture		2	2
		1ichael Sch	ılüter					
Admission Requirements	None							
Recommended Previous Knowledge	•		wledge in F	luid Mechanic hemical thern				
Educational Objectives	After t	aking part	successful	ly, students h	ave reached	the follo	wing learn	ing results
Professional Competence				of the modul				
Knowledge	<ul> <li>explain the the basic principles of statistical thermodynamics (ensemble simple systems)</li> <li>describe the main approaches in classical Molecular Modeling (Monte Carlo Molecular Dynamics) in various ensembles</li> <li>discuss examples of computer programs in detail,</li> <li>evaluate the application of numerical simulations,</li> <li>list the possible start and boundary conditions for a numerical simulation.</li> </ul>							
Skills	•	molecular solve prob set up a n perform a	mputer pro dynamics, plems by m umerical gr simple nur	ograms for so olecular mode rid, merical simula f a numerical	eling, ation with Op	·	·	nte Carlo
Personal Competence								
Social Competence	•	students,	oint solution	ns in mixed te	•			
Autonomy	•	on that ba	heir learnii sis,	ng progress a nsequences fo			wing steps	s of learnir

Credit points	6
Course achievement	INODE
Examination	Oral exam
Examination duration and scale	30 min
the Following	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

avT	Lecture
Hrs/wk	
СР	
<b>Norkload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Alexandra von Kameke
Language	
Cycle	
	Contents
	- Common variables and terms for characterizing turbulence (energy spectra energy cascade, etc.)
	- An overview of Lagrange analysis methods and experiments in fluid mechanics
	- Critical examination of the concept of turbulence and turbulent structures.
	-Calculation of the transport of ideal fluid elements and associated analysis method (absolute and relative diffusion, Lagrangian Coherent Structures, etc.)
	- Implementation of a Runge-Kutta 4th-order in Matlab
	- Introduction to particle integration using ODE solver from Matlab
	- Problems from turbulence research
	- Application analytical methods with Matlab.
	Structure:
	- 14 units a 2x45 min.
	- 10 units lecture

- 4 Units Matlab Exercise- Go through the exercises Matlab, Peer2Peer? Explain solutions to your colleague

## Content

Learning goals:

Students receive very specific, in-depth knowledge from modern turbulence research and transport analysis. → Knowledge

The students learn to classify the acquired knowledge, they study approaches to further develop the knowledge themselves and to relate different data sources to each other. → Knowledge, skills

The students are trained in the personal competence to independently delve into and research a scientific topic. → Independence

Matlab exercises in small groups during the lecture and guided Peer2Peer discussion rounds train communication skills in complex situations. The mixture of precise language and intuitive understanding is learnt. → Knowledge, social competence

Required knowledge:

Fluid mechanics 1 and 2 advantageous

Programming knowledge advantageous

Bakunin, Oleg G. (2008): Turbulence and Diffusion. Scaling Versus Equations. Berlin [u. a.]: Springer Verlag.

Bourgoin, Mickaël; Ouellette, Nicholas T.; Xu, Haitao; Berg, Jacob; Bodenschatz, Eberhard (2006): The role of pair dispersion in turbulent flow. In: Science (New York, N.Y.) 311 (5762), S. 835-838. DOI: 10.1126/science.1121726.

Davidson, P. A. (2015): Turbulence. An introduction for scientists and engineers. Second edition. Oxford: Oxford Univ. Press.

Graff, L. S.; Guttu, S.; LaCasce, J. H. (2015): Relative Dispersion in the Atmosphere from Reanalysis Winds. In: J. Atmos. Sci. 72 (7), S. 2769-2785. DOI: 10.1175/JAS-D-14-0225.1.

Grigoriev, Roman (2011): Transport and Mixing in Laminar Flows. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA.

Haller, George (2015): Lagrangian Coherent Structures. In: Annu. Rev. Fluid Mech. 47 (1), S. 137-162. DOI: 10.1146/annurev-fluid-010313-141322.

Kameke, A. von; Huhn, F.; Fernández-García, G.; Muñuzuri, A. P.; Pérez-Muñuzuri, V. (2010): Propagation of a chemical wave front in a quasi-two-dimensional superdiffusive flow. In: Physical review. E, Statistical, nonlinear, and soft matter physics 81 (6 Pt 2), S. 66211. DOI: 10.1103/PhysRevE.81.066211.

Kameke, A. von; Huhn, F.; Fernández-García, G.; Muñuzuri, A. P.; Pérez-Muñuzuri, V. (2011): Double cascade turbulence and Richardson dispersion in a horizontal fluid flow induced by Faraday waves. In: Physical review letters 107 (7), S. 74502. DOI: 10.1103/PhysRevLett.107.074502.

Literature Kameke, A.v.; Kastens, S.; Rüttinger, S.; Herres-Pawlis, S.; Schlüter, M. (2019): How coherent structures dominate the residence time in a bubble wake: An experimental example. In: Chemical Engineering Science 207, S. 317-326. 10.1016/j.ces.2019.06.033.

Klages, Rainer; Radons, Günter; Sokolov, Igor M. (2008): Anomalous Transport: Wiley.

LaCasce, J. H. (2008): Statistics from Lagrangian observations. In: Progress in Oceanography 77 (1), S. 1-29. DOI: 10.1016/j.pocean.2008.02.002.

Neufeld, Zoltán; Hernández-García, Emilio (2009): Chemical and Biological Processes in Fluid Flows: PUBLISHED BY IMPERIAL COLLEGE PRESS AND DISTRIBUTED BY WORLD SCIENTIFIC PUBLISHING CO.

Onu, K.; Huhn, F.; Haller, G. (2015): LCS Tool: A computational platform for Lagrangian coherent structures. In: Journal of Computational Science 7, S. 26-36. DOI: 10.1016/j.jocs.2014.12.002.

Ouellette, Nicholas T.; Xu, Haitao; Bourgoin, Mickaël; Bodenschatz, Eberhard (2006): An experimental study of turbulent relative dispersion models. In: New J. Phys. 8 (6), S. 109. DOI: 10.1088/1367-2630/8/6/109.

Pope, Stephen B. (2000): Turbulent Flows. Cambridge: Cambridge University Press.

Rivera, M. K.; Ecke, R. E. (2005): Pair dispersion and doubling time statistics in two-dimensional turbulence. In: Physical review letters 95 (19), S. 194503. DOI: 10.1103/PhysRevLett.95.194503.

Vallis, Geoffrey K. (2010): Atmospheric and oceanic fluid dynamics. Fundamentals and large-scale circulation. 5. printing. Cambridge: Cambridge Univ. Press.

Course L1375: Computational Fluid Dynamics - Exercises in OpenFoam				
Тур	Recitation Section (small)			
Hrs/wk	1			
СР	1			
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14			
Lecturer	Prof. Michael Schlüter			
Language	EN			
Cycle	SoSe			
Content	<ul> <li>generation of numerical grids with a common grid generator</li> <li>selection of models and boundary conditions</li> <li>basic numerical simulation with OpenFoam within the TUHH CIP-Pool</li> </ul>			
Literature	OpenFoam Tutorials (StudIP)			

Course L1052: Com	nputational Fluid Dynamics in Process Engineering
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	<ul> <li>Introduction into partial differential equations</li> <li>Basic equations</li> <li>Boundary conditions and grids</li> <li>Numerical methods</li> <li>Finite difference method</li> <li>Finite volume method</li> <li>Time discretisation and stability</li> <li>Population balance</li> <li>Multiphase Systems</li> <li>Modeling of Turbulent Flows</li> <li>Exercises: Stability Analysis</li> <li>Exercises: Example on CFD - analytically/numerically</li> </ul>
Literature	Paschedag A.R.: CFD in der Verfahrenstechnik: Allgemeine Grundlagen und mehrphasige Anwendungen, Wiley-VCH, 2004 ISBN 3-527-30994-2.  Ferziger, J.H.; Peric, M.: Numerische Strömungsmechanik. Springer-Verlag, Berlin, 2008, ISBN: 3540675868.  Ferziger, J.H.; Peric, M.: Computational Methods for Fluid Dynamics. Springer, 2002, ISBN 3-540-42074-6

Module M051	1: Electricity Generat	ion from Wind an	d Hydro Po	wer
Courses				
Title		Тур	Hrs/wk	СР
Sustainability Manage	ment (L0007)	Lecture	2	1
Hydro Power Use (L00		Lecture	1	1
Wind Turbine Plants (L		Lecture	2	3
Wind Energy Use - Foo		Lecture	1	1
Module Responsible	Dr. Isabel Höfer			
Admission Requirements	LNODE			
	Module: Technical Thermodyna	amics I,		
Recommended		amics II		
Previous Knowledge				
Kilowieuge	Module: Fundamentals of Fluid	Mechanics		
Educational Objectives	After taking part successfully,	students have reached the	e following learn	ing results
Professional				
Competence	;			
Knowledge	By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe.  Through active discussions of various topics within the seminar of the module students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.			
Skills	Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplar theoretical projects.			
Personal Competence				
Social Competence	Students can discuss scientific tasks subjet-specificly and multidisciplinary within a			
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.			
Workload in Hours	Independent Study Time 96, S	tudy Time in Lecture 84		
Credit points	6			
Course achievement		_		
Examination	Written exam			
Examination duration and scale	2.5 hours written exam + Pren	sentation in sustainability	management	
Scale	<u> </u>			

Course L0007: Sus	tainability Management
Тур	Lecture
Hrs/wk	2
СР	1
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Anne Rödl
Language	DE
Cycle	WiSe
Content	The lecture sustainability management provide an insight into the various aspects and dimensions of sustainability. This content of the course is based on the foundations of environmental assessment; therefore the previous attendance of the lecture environmental assessment is recommended. Various valuation approaches for assessing environmental, economic and social aspects are presented. Their application and use for a sustainability management's discussion is explained by means of short technology examples and is later comprehensively presented through case examples.  • Introduction to the topic of sustainability • Dimensions of sustainability:  • ecology  • economics  • social • Transition from the environmental assessment for sustainability management  • Case Studies • Excursion  Objective: The aim of the course is to learn methods for the assessment of sustainability aspects and apply for sustainability management.
Literature	Engelfried, J. (2011) Nachhaltiges Umweltmanagement. München: Oldenbourg Verlag. 2. Auflage  Corsten H., Roth S. (Hrsg.) (2011) Nachhaltigkeit - Unternehmerisches Handeln in globaler Verantwortung. Wiesbaden: Gabler Verlag.

Course L0013: Hydro Power Use			
Тур	Lecture		
Hrs/wk	1		
СР	1		
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Stephan Heimerl		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>Introduction, importance of water power in the national and global context</li> <li>Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies</li> <li>Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems</li> <li>Construction of hydroelectric power plants: description of the individual components and their technical system interaction</li> <li>Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc.</li> <li>Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection</li> <li>Hydropower and the Environment</li> <li>Examples from practice</li> </ul>		
Literature	<ul> <li>Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage</li> <li>Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage</li> <li>Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage</li> <li>von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage</li> <li>Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006</li> </ul>		

Course L0011: Wind Turbine Plants			
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Dr. Rudolf Zellermann		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>Historical development</li> <li>Wind: origins, geographic and temporal distribution, locations</li> <li>Power coefficient, rotor thrust</li> <li>Aerodynamics of the rotor</li> <li>Operating performance</li> <li>Power limitation, partial load, pitch and stall control</li> <li>Plant selection, yield prediction, economy</li> <li>Excursion</li> </ul>		
Literature	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005		

Course L0012: Win	d Energy Use - Focus Offshore
Тур	Lecture
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Skiba
Language	DE
Cycle	SoSe
Content	<ul> <li>Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering</li> <li>Physical fundamentals for utilization of wind energy</li> <li>Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships</li> <li>Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures</li> <li>Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection</li> <li>Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics</li> <li>Development and planning of offshore wind farms</li> <li>Operation and optimization of offshore wind farms</li> <li>Day excursion</li> </ul>
Literature	<ul> <li>Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage</li> <li>Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidelberg, 1997, 3. Auflage</li> <li>Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage</li> <li>Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage</li> <li>Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage</li> </ul>

Module M0508	3: Fluid Mechani	ics and Ocear	n Energy		
Courses					
Title Energy from the Ocean		I	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 2
Fluid Mechanics II (L00			Lecture	2	4
Admission Requirements	None				
	Technische Thermodyn Wärme- und Stoffübert				
Educational Objectives	After taking part succes	ssfully, students ha	ve reached the follo	wing learn	ing results
Professional Competence					
Knowledge	The students are able to describe different applications of fluid mechanics for the field of Renewable Energies. They are able to use the fundamentals of fluid mechanics for calculations of certain engineering problems in the field of ocean energy. The students are able to estimate if a problem can be solved with an analytical solution and what kind of alternative possibilities are available (e.g. self-similarity, empirical solutions, numerical methods).				
Skills	Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are able to formulate momentum and mass balances to optimize the hydrodynamics of technical processes. They are able to transform a verbal formulated message into an abstract formal procedure.				
Personal Competence					
Social Competence	The students are able tapproach. They are able the results and to present	le to solve a proble			
Autonomy	Students are able to define independently tasks for problems related to fluid mechanics. They are able to work out the knowledge that is necessary to solve the problem by themselves on the basis of the existing knowledge from the lecture.				
Workload in Hours	Independent Study Tim	ne 124, Study Time	in Lecture 56		
Credit points	6				
Course achievement	CompulsorBonus Yes 10 %	<b>Form</b> Group discussion	Descript	ion	
Examination	Written exam				
Examination duration and scale					
Assignment for the Following Curricula	Energy Systems: Core of International Managem Elective Compulsory Renewable Energies: C Theoretical Mechanica Compulsory Theoretical Mechanica Compulsory	nent and Engineer fore qualification: Coal Engineering: S	ing: Specialisation I ompulsory pecialisation Energ	ıy System	s: Elective

Course L0002: Ener	rgy from the Ocean
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE
Cycle	WiSe
Content	<ol> <li>Introduction to ocean energy conversion</li> <li>Wave properties         <ul> <li>Linear wave theory</li> <li>Nonlinear wave theory</li> <li>Irregular waves</li> <li>Wave energy</li> <li>Refraction, reflection and diffraction of waves</li> </ul> </li> <li>Wave energy converters         <ul> <li>Overview of the different technologies</li> <li>Methods for design and calculation</li> </ul> </li> <li>Ocean current turbine</li> </ol>
Literature	<ul> <li>Cruz, J., Ocean wave energy, Springer Series in Green Energy and Technology, UK, 2008.</li> <li>Brooke, J., Wave energy conversion, Elsevier, 2003.</li> <li>McCormick, M.E., Ocean wave energy conversion, Courier Dover Publications, USA, 2013.</li> <li>Falnes, J., Ocean waves and oscillating systems, Cambridge University Press, UK, 2002.</li> <li>Charlier, R. H., Charles, W. F., Ocean energy. Tide and tidal Power. Berlin, Heidelberg, 2009.</li> <li>Clauss, G. F., Lehmann, E., Östergaard, C., Offshore Structures. Volume 1, Conceptual Design. Springer-Verlag, Berlin 1992</li> </ul>

Course L0001: Flui	d Mechanics II
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
	Prof. Michael Schlüter
Language	DE
Cycle	
Content	<ul> <li>Differential equations for momentum-, heat and mass transfer</li> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> <li>Coupling of momentum and heat transfer - Thermal Process Engineering</li> <li>Rheology - Bioprocess Engineering</li> <li>Coupling of momentum- and mass transfer - Reactive mixing, Chemical Process Engineering</li> <li>Flow threw porous structures - heterogeneous catalysis</li> <li>Pumps and turbines - Energy- and Environmental Process Engineering</li> <li>Wind- and Wave-Turbines - Renewable Energy</li> <li>Introduction into Computational Fluid Dynamics</li> </ul>
Literature	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.</li> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994.</li> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.</li> <li>Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.</li> <li>Kuhlmann, H.C.: Strömungsmechanik: München, Pearson Studium, 2007</li> <li>Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.</li> <li>Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.</li> <li>Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.</li> <li>Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.</li> <li>van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> </ol>

Module M051	5: Energy Information Syste	ms and Ele	ectromobili	ty
Courses				
Title Electrical Power System Electrical Power Grids Electro mobility (L183)		Typ Lecture Lecture	<b>Hrs/wk</b> 2 2	<b>CP</b> 4 2
1100 P 0 1101 W 10				
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students h	nave reached th	e following learn	ing results
Professional Competence <i>Knowledge</i>	Students are able to give an overview of the electric power engineering in the field of renewable energies. They can explain in detail the possibilities for the integration of renewable energy systems into the existing grid, the electrical storage possibilities and the electric power transmission and distribution, and can take critically a stand on it.			
Skills	With completion of this module the students are able to apply the acquired skills in applications of the design, integration, development of renewable energy systems and to assess the results.			
Personal Competence Social Competence				discussions,
Autonomy	Students can independently tap knowledge of the emphasis of the lectures.			
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and scale				
the Following	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory			

Course L1696: Elec Power Grids	ctrical Power Systems II: Operation and Information Systems of Electrical
Тур	Lecture
Hrs/wk	2
СР	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	<ul> <li>steaedy-state modelling of electric power systems         <ul> <li>conventional components</li> <li>Flexible AC Transmission Systems (FACTS) and HVDC</li> <li>grid modelling</li> </ul> </li> <li>grid operation         <ul> <li>electric power supply processes</li> <li>grid and power system management</li> <li>grid control systems</li> <li>information and communication systems for power system management</li> <li>IT architectures of bay-, substation and network control level</li> <li>IT integration (energy market / supply shortfall management / asset management)</li> <li>future trends of process control technology</li> <li>smart grids</li> </ul> </li> <li>functions and steady-state computations for power system operation and plannung         <ul> <li>load-flow calculations</li> <li>sensitivity analysis and power flow control</li> <li>power system optimization</li> <li>short-circuit calculation</li> <li>asymmetric failure calculation</li> <li>asymmetric components</li> <li>calculation of asymmetric failures</li> <li>state estimation</li> </ul> </li> </ul>
Literature	E. Handschin: Elektrische Energieübertragungssysteme, Hüthig Verlag B. R. Oswald: Berechnung von Drehstromnetzen, Springer-Vieweg Verlag V. Crastan: Elektrische Energieversorgung Bd. 1 & 3, Springer Verlag EG. Tietze: Netzleittechnik Bd. 1 & 2, VDE-Verlag

Course L1833: Electro mobility			
Тур	Lecture		
Hrs/wk	2		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Dr. Klaus Bonhoff		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>Vehicle Integration</li> <li>Energy consumption of electric cars</li> <li>Battery life</li> <li>Charging Infrastructure</li> <li>Electric road transport</li> <li>Electric public transport</li> <li>Battery Safety</li> </ul>		
Litowat	Verlegunggunterlagen/ legture material		
Literature	Vorlesungsunterlagen/ lecture material		

Module M1149	9: Marine Power Engineerii	ng			
Courses					
<b>Title</b> Electrical Installation o	·	<b>Typ</b> Lecture Recitation	Section	Hrs/wk	<b>CP</b> 2
Electrical Installation o	·	(large)	3000.011	-	1
Marine Engineering (L1		Lecture Recitation	Section	2	2
Marine Engineering (L1	1570)	(large)	Section	1	1
Module Responsible	Prof. Christopher Friedrich Wirz				
Admission Requirements	None				
Recommended Previous Knowledge					
Educational Objectives		have reached	the follow	wing learn	ing results
Professional Competence					
Knowledge	The students are able to describe the state-of-the-art regarding the wide range of propulsion components on ships and apply their knowledge. They further know how to analyze and optimize the interaction of the components of the propulsion system and how to describe complex correlations with the specific technical terms in German and English. The students are able to name the operating behaviour of consumers, describe special requirements on the design of supply networks and to the electrical equipment in isolated networks, as e.g. onboard ships, offshore units, factories and emergency power supply systems, explain power generation and distribution in isolated grids, wave generator systems on ships, and name requirements for network protection, selectivity and operational monitoring.				
Skills	The students are skilled to employ reciprocating machinery, their selecting further able to assess, analyse and some propulsion and auxiliary plants and thave the skills to describe complex controlled disciplines. Students are able than design electrical propulsion system	on and operated to the technical of the	ion on b and opera Julsion sy I bring th	oard ship ational pro stems. The nem into c	s. They are oblems with he students context with
Personal Competence Social Competence	The students are able to communicate in the shipbuilding and component sup		e in a prof	fessional e	environment
Autonomy	The widespread scope of gained ki situations in their future profession ind				to handle
Workload in Hours	Independent Study Time 96, Study Tim	e in Lecture 84	1		
Credit points	6				
Course achievement	None				
Examination	Written exam				

Examination duration and scale	90 minutes plus 20 minutes oral exam
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1531: Elec	trical Installation on Ships
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	<ul> <li>performance in service of electrical consumers.</li> <li>special requirements for power supply systems and for electrical equipment in isolated systems/networks e. g. aboard ships, offshore installations, factory systems and emergency power supply systems.</li> <li>power generation and distribution in isolated networks, shaft generators for ships</li> <li>calculation of short circuits and behaviour of switching devices</li> <li>protective devices, selectivity monitoring</li> <li>electrical Propulsion plants for ships</li> </ul>
Literature	H. Meier-Peter, F. Bernhardt u. a.: Handbuch der Schiffsbetriebstechnik, Seehafen Verlag (engl. Version: "Compendium Marine Engineering") Gleß, Thamm: Schiffselektrotechnik, VEB Verlag Technik Berlin

Course L1532: Electrical Installation on Ships		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Günter Ackermann	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1569: Marine Engineering	
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	WiSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1570: Marine Engineering		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Christopher Friedrich Wirz	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

## **Specialization Aircraft Systems Engineering**

Central to the specialization Aircraft Systems is learning the ability to systems engineering and cross-divisional thinking and problem solving in aeronautical engineering. This is made possible by modules in the field of physics of flight, aircraft systems and cabin systems, Aircraft Design, as well as airport planning and operation in the elective area. In addition, subjects in the Technical Supplement Course for TMBMS (according FSPO) are freely selectable.

35) 39)	<b>Typ</b> Lecture	Hrs/wk	СР
	Recitation	3 Section <sub>2</sub>	4
Prof. Frank Thielecke	(large)		
None			
Basic knowledge in:  Mathematics Mechanics Thermodynamics Electrical Engineering Hydraulics Control Systems			
After taking part successfully	y, students have reached	I the following learn	ning result
<ul><li>high-lift systems</li><li>Give an overview of the Explain the need for h</li></ul>	ne functionality of air cor nigh-lift systems such as	nditioning systems ist functionality and	d effects
<ul> <li>Design high-lift syster</li> </ul>	ns of aircrafts		s
Students are able to:			
	None  Basic knowledge in:	None  Basic knowledge in:  Mathematics Mechanics Thermodynamics Electrical Engineering Hydraulics Control Systems  After taking part successfully, students have reached  Students are able to: Describe essential components and design poligh-lift systems Give an overview of the functionality of air core Explain the need for high-lift systems such as Assess the challenge during the design of suppositions are able to: Design hydraulic and electric supply systems of Design high-lift systems of aircrafts Design high-lift systems of aircrafts Analyze the thermodynamic behaviour of air constitutions.	None  Basic knowledge in:  Mathematics Mechanics Thermodynamics Electrical Engineering Hydraulics Control Systems  After taking part successfully, students have reached the following learn  Students are able to: Describe essential components and design points of hydraulic, e high-lift systems Give an overview of the functionality of air conditioning systems Explain the need for high-lift systems such as ist functionality and Assess the challenge during the design of supply systems of an air  Students are able to: Design hydraulic and electric supply systems of aircrafts Design high-lift systems of aircrafts Analyze the thermodynamic behaviour of air conditioning systems

Autonomy	Reflect the contents of lectures autonomously	
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70	
Credit points	6	
Course achievement	None	
Examination	Written exam	
Examination duration and scale	165 Minutes	
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory	

Course L0735: Airc	raft Systems I
	Lecture
Hrs/wk	
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	WiSe
Content	<ul> <li>Hydraulic Energy Systems (Fluids; pressure loss in valves and pipes; components of hydraulic systems like pumps, valves, etc.; pressure/flow characteristics; actuators; tanks; power and heat balances; emergency power)</li> <li>Electric Energy Systems (Generators; constant-speed-drives; DC and AC converters; electrical power distribution; bus systems; monitoring; load analysis)</li> <li>High Lift Systems (Principles; investigation of loads and system actuation power; principles and sizing of actuation and positioning systems; safety requirements and devices)</li> <li>Environmental Control Systems (Thermodynamic analysis; expansion and compression cooling systems; control strategies; cabin pressure control systems)</li> </ul>
Literature	<ul> <li>Moir, Seabridge: Aircraft Systems</li> <li>Green: Aircraft Hydraulic Systems</li> <li>Torenbek: Synthesis of Subsonic Airplane Design</li> <li>SAE1991: ARP; Air Conditioning Systems for Subsonic Airplanes</li> </ul>

Course L0739: Aircraft Systems I		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Frank Thielecke	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0812	2: Aircraft Design			
Courses				
Aircraft Design II (Conc operations aircraft, UA Aircraft Design II (Conc operations aircraft, UA	ceptual Design of Rotorcraft, special V) (L0847)	Typ Lecture Lecture Recitation (large) Recitation	Hrs/wk 2 2 Section 1 Section 1	<b>CP</b> 2 2 1
Aircraft Design I (L083	4)	(large)	1	1
Module Responsible	Prof. Volker Gollnick			
Admission Requirements	None			
Recommended Previous Knowledge	<ul><li>Vordiplom Mech. Eng.</li><li>Module Air Transport Systems</li></ul>			
Educational Objectives	After taking part successfully, students	have reached	the following learn	ing results
Professional Competence				
Knowledge	<ol> <li>Principle understanding of integrated aircraft design</li> <li>Understanding of the interactions and contributions of the various disciplines</li> <li>Impact of the relevant design parameter on the aircraft design</li> <li>Introduction of the principle design methods</li> </ol>			
Skills	Understanding and application of design and calculation methods  Understanding of interdisciplinary and integrative interdependencies			
Personal Competence				
Social Competence	Working in interdisciplinary teams  Communication			
	Organization of workflows and -strateg			
	Independent Study Time 96, Study Tim	e in Lecture 84	1	
Credit points				
Course achievement	None			
Examination				
Examination duration and scale				
	Aircraft Systems Engineering: Core qua International Management and Engin Elective Compulsory Product Development, Materials Development: Elective Compulsory Theoretical Mechanical Engineering: Compulsory Theoretical Mechanical Engineering: States	eering: Special and Product	ion: Specialisation	on Product

Course L0820: Aircraft Design I (Design of Transport Aircraft)		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Volker Gollnick	
Language	DE	
Cycle	WiSe	
Content	<ol> <li>Introduction into the aircraft design process</li> <li>Introduction/process of aircraft design/various aircraft configurations</li> <li>Requirements and design objectives, main design parameter (u.a. payload-range-diagramme)</li> <li>Statistical methods in overall aircraft design/data base methods</li> <li>Principles of aircraft performance design (stability, V-n-diagramme)</li> <li>Principles of aerodynamic aircraft design (polar, geometry, 2D/3D aerodynamics)</li> <li>Principles of structural fuselage and wing design (mass analysis, beam/tube models, geometry)</li> <li>Principles of engine design and integration</li> <li>Cruise design</li> <li>Design of runway and landing field length</li> <li>Cabin design (fuselage dimensioning, cabin interior, loading systems)</li> <li>System- and equipment aspects</li> <li>Design variations and operating cost calculation</li> </ol>	
Literature	J. Roskam: "Airplane Design"  D.P. Raymer: "Aircraft Design - A Conceptual Approach"  J.P. Fielding: "Intorduction to Aircraft Design"  Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"	

Course L0844: Airc	raft Design II (Conceptual Design of Rotorcraft, special operations aircraft,
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Volker Gollnick, Dr. Bernd Liebhardt
Language	
Cycle	SoSe
Content	Take Off and landing  Loads on Aircraft  Operation Cost  Principles of Rotorcraft Design  Principles of high performance aircraft design  Principles of special operations aircraft design  Principles of Unmanned Air Systems design
Literature	Gareth Padfield: Helicopter Flight Dynamics Raymond Prouty: Helicopter Performance Stability and Control Klaus Hünecke: Das Kampfflugzeug von Heute

Course L0847: Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV)			
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	1		
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Volker Gollnick, Dr. Bernd Liebhardt		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L0834: Aircraft Design I		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Volker Gollnick	
Language	DE	
Cycle	WiSe	
Content	Training in applying MatLab  Application of design methods for civil aircraft concerning:  Fuselage and Cabin sizing and design  Calculation of aircraft masses  Aerodynamic and geometric wing design  TakeOff, landing cruise performance calculation  Manoevre and gust load calculation	
Literature	J. Roskam: "Airplane Design"  D.P. Raymer: "Aircraft Design - A Conceptual Approach"  J.P. Fielding: "Intorduction to Aircraft Design"  Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"	

Module M077	L: Flight Physics			
Courses				
<b>Title</b> Aerodynamics and Flig Flight Mechanics II (L0) Flight Mechanics II (L0)		<b>Typ</b> Lecture Lecture Recitation (large)	Hrs/wk 3 2 Section 1	<b>CP</b> 3 2
Module Responsible	Prof. Frank Thielecke	(		
Admission Requirements	None			
Recommended Previous Knowledge	Mechanics			
Educational Objectives	After taking part successfully, students	have reached	the following lear	ning results
Professional Competence <i>Knowledge</i> <i>Skills</i>				
Personal Competence Social Competence Autonomy				
	Independent Study Time 96, Study Tim	e in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 Minutes (WS) + 90 Minutes (SS)			
the Following	Aircraft Systems Engineering: Core qua International Management and Engin Elective Compulsory Product Development, Materials Development: Elective Compulsory Product Development, Materials and P Compulsory Product Development, Materials and I Compulsory Theoretical Mechanical Engineering: Selective Compulsory Theoretical Mechanical Engineering: Compulsory	and Production: Special Production: Specialisation	ion: Specialisation: Specialisation Product ecialisation Mater Aircraft Systems	on Product tion: Elective ials: Elective Engineering:

Course L0727: Aerodynamics and Flight Mechanics I			
Тур	Lecture		
Hrs/wk	3		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42		
Lecturer	Prof. Frank Thielecke, Dr. Ralf Heinrich, Mike Montel		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>Aerodynamics (fundamental equations of aerodynamics; compressible and incompressible flows; airfoils and wings; viscous flows)</li> <li>Flight Mechanics (Equations of motion; flight performance; control surfaces; derivatives; lateral stability and control; trim conditions; flight maneuvers)</li> </ul>		
Literature	<ul> <li>Schlichting, H.; Truckenbrodt, E.: Aerodynamik des Flugzeuges I und II</li> <li>Etkin, B.: Dynamics of Atmospheric Flight</li> <li>Sachs/Hafer: Flugmechanik</li> <li>Brockhaus: Flugregelung</li> <li>J.D. Anderson: Introduction to flight</li> </ul>		

Course L0730: Flig	ht Mechanics II
	Lecture
Hrs/wk	
СР	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
	Prof. Frank Thielecke, Mike Montel
Language	
Cycle	SoSe
Content	<ul> <li>stationary asymmetric flight</li> <li>dynamics of lateral movement</li> <li>methods of flight simulation</li> <li>eyperimental methods of flight mechanics</li> <li>model validation using system identification</li> <li>wind tunnel techniques</li> </ul>
Literature	<ul> <li>Schlichting, H.; Truckenbrodt, E.: Aerodynamik des Flugzeuges I und II</li> <li>Etkin, B.: Dynamics of Atmospheric Flight</li> <li>Sachs/Hafer: Flugmechanik</li> <li>Brockhaus: Flugregelung</li> <li>J.D. Anderson: Introduction to flight</li> </ul>

Course L0731: Flight Mechanics II		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Frank Thielecke, Mike Montel	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

	2: Technical Elective Course for TMBMS (according to fic Regulations)
Courses	
Title	Typ Hrs/wk CP
Kesponsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	see FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
:	see FSPO
Personal Competence	
Social Competence	see FSPO
Autonomy	see FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Module M1156	6: Systems Engineering				
Courses					
<b>Title</b> Systems Engineering (	L1547)	<b>Typ</b> Lecture		Hrs/wk	<b>CP</b> 4
Systems Engineering (	L1548)	Recitation (large)	Section	1	2
Module Responsible	Prof. Ralf God				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge in:  • Mathematics  • Mechanics  • Thermodynamics  • Electrical Engineering  • Control Systems  Previous knowledge in:  • Aircraft Cabin Systems				
Educational Objectives	After taking part successfully, students h	nave reached	the follo	wing learn	ing results
Professional Competence					
Knowledge	Students are able to:  • understand systems engineering process models, methods and tools for the development of complex Systems  • describe innovation processes and the need for technology Management  • explain the aircraft development process and the process of type certification for aircraft  • explain the system development process, including requirements for systems reliability  • identify environmental conditions and test procedures for airborne Equipment  • value the methodology of requirements-based engineering (RBE) and model-based requirements engineering (MBRE)				
Skills	Students are able to: • plan the process for the development of complex Systems • organize the development phases and development Tasks • assign required business activities and technical Tasks • apply systems engineering methods and tools				
Personal Competence					
Social Competence	Students are able to: • understand their responsibilities within a development team and integrate themselves with their role in the overall process				
Autonomy	Students are able to: • interact and communicate in a development team which has distributed tasks				
	Independent Study Time 124, Study Tim	e in Lecture 5	56		
Credit points					
Course achievement	None				
Examination	Written exam				
Examination duration and					

scale						
	Aircraft Systems Engineering: Core qualification: Compulsory					
	nternational Management and Engineering: Specialisation II. Aviation Systems:					
	Elective Compulsory					
	International Management and Engineering: Specialisation II. Product Development					
	and Production: Elective Compulsory					
	Mechatronics: Specialisation System Design: Elective Compulsory					
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					
_	Product Development, Materials and Production: Specialisation Product					
_	Development: Compulsory					
Curricula	Product Development, Materials and Production: Specialisation Production: Elective					
	Compulsory					
	Product Development, Materials and Production: Specialisation Materials: Elective					
	Compulsory					
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective					
	Compulsory The author Machanical Engineering Creatistics Aircraft Customs Engineering					
	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering:					
	Elective Compulsory					

Course L1547: Syst	tems Engineering
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integration of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineering process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known.  Key aspects of the course are processes for innovation and technology management, system design, system integration and certification as well as tools and methods for systems engineering:  Innovation processes  IP-protection  Technology management  Systems engineering  Aircraft program  Certification issues  Systems development  Safety objectives and fault tolerance Environmental and operating conditions  Tools for systems engineering  Requirements-based engineering (RBE)  Model-based requirements engineering (MBRE)
Literature	<ul> <li>Skript zur Vorlesung</li> <li>diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE)</li> <li>Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010</li> <li>NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007</li> <li>Hinsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation luftfahrttechnischer Betriebe. Springer, 2010</li> <li>De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010</li> <li>Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt. Verlag, 2008</li> </ul>

Course L1548: Systems Engineering		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0764	4: Flight Control System	s (FS2)		
Courses				
Title Aircraft Systems II (L0) Aircraft Systems II (L0)		<b>Typ</b> Lecture Recitation (large)	Hrs/wk 3 Section 2	<b>CP</b> 4 2
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None			
Recommended Previous Knowledge	thermo dynamics			
Educational Objectives	After taking part successfully, stude	ents have reached t	the following lear	ning results
Professional Competence				
Knowledge	<ul> <li>Students are able to</li> <li>describe the structure of primary flight control systems as well as actuation-, avionic-, high lift systems in general along with corresponding properties and applications.</li> <li>explain different configurations and designs and their origins</li> </ul>			
Skills	Students are able to  • size primary flight control actuation systems  • perform a controller design process for the flight control actuators  • design high-lift kinematics			
Personal Competence	Students are able to:			
Social Competence	Develop joint solutions in mix	xed teams		
Autonomy	Students are able to:  derive requirements and per for aircraft systems from comanner			
Workload in Hours	Independent Study Time 110, Study	y Time in Lecture 7	0	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				

	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory
	Product Development, Materials and Production: Specialisation Product
	Development: Elective Compulsory
Assignment for	Product Development, Materials and Production: Specialisation Production: Elective
the Following	Compulsory
Curricula	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory

Course L0736: Airc	raft Systems II
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	SoSe
Content	<ul> <li>Actuation (Principles of actuators; electro-mechanical actuators; modeling, analysis and sizing of position control systems; hydro-mechanic actuation systems)</li> <li>Flight Control Systems (control surfaces, hinge moments; requirements of stability and controllability, actuation power; principles of reversible and irreversible flight control systems; servo actuation systems)</li> <li>Landing Gear Systems (Configurations and geometries; analysis of landing gear systems with respect to damper dynamics, dynamics of the breaking aircraft and power consumption; design and analysis of breaking systems with respect to energy and heat; anti-skit systems)</li> <li>Fuel Systems (Architectures; aviation fuels; system components; fueling system; tank inerting system; fuel management; trim tank)</li> <li>De- and Anti-Ice Systems: (Atmospheric icing conditions; principles of de- and anti-ice systems)</li> </ul>
Literature	<ul> <li>Moir, Seabridge: Aircraft Systems</li> <li>Torenbek: Synthesis of Subsonic Airplane Design</li> <li>Curry: Aircraft Landing Gear Design: Principles and Practices</li> </ul>

Course L0740: Aircraft Systems II		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Frank Thielecke	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M115	5: Aircraft Cabin Systems			
Courses				
<b>Title</b> Aircraft Cabin Systems	s (L1545)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 4
Aircraft Cabin Systems	s (L1546)	Recitation (large)	Section 1	2
Module Responsible	IPIOL BAILGOO			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:  • Mathematics  • Mechanics  • Thermodynamics  • Electrical Engineering  • Control Systems			
Educational Objectives	LATTER TAKING NART SUCCESSIUM STUGENTS	s have reached	the following learn	ing results
Professional				
<b>Competence</b> <i>Knowledge</i>	Students are able to:  • describe cabin operations, equipment in the cabin and cabin Systems  • explain the functional and non-functional requirements for cabin Systems  • elucidate the necessity of cabin operating systems and emergency Systems  • assess the challenges human factors integration in a cabin environment			
Skills	Students are able to:  • design a cabin layout for a given business model of an Airline  • design cabin systems for safe operations  • design emergency systems for safe man-machine interaction  • solve comfort needs and entertainment requirements in the cabin			
Personal Competence	Students are able to:			
Social Competence	understand existing system solutions	s and discuss th	eir ideas with expe	erts
Autonomy	Students are able to: • Reflect the contents of lectures and	expert presenta	itions self-depende	nt
Workload in Hours	Independent Study Time 124, Study Ti	ime in Lecture 5	66	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 Minutes			
Assignment for	Electrical Engineering: Specialisation Elective Compulsory Energy Systems: Specialisation Energy Aircraft Systems Engineering: Core qualinternational Management and Engineerive Compulsory Product Development, Materials Development: Elective Compulsory	/ Systems: Elect alification: Com neering: Specia	cive Compulsory pulsory alisation II. Aviatio	n Systems:
	[138]			

Compulsory

the Following	Product Development, Materials and Production: Specialisation Production: Elective
Curricula	Compulsory
	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering:
	Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective

Course L1545: Airc	raft Cabin Systems
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about aircraft cabin systems and cabin operations. A basic understanding of technological and systems engineering effort to maintain an artificial but comfortable and safe travel and working environment at cruising altitude is to be achieved.  The course provides a comprehensive overview of current technology and cabin systems in modern passenger aircraft. The Fulfillment of requirements for the cabin as the central system of work are covered on the basis of the topics comfort, ergonomics, human factors, operational processes, maintenance and energy supply:  • Materials used in the cabin • Ergonomics and human factors • Cabin interior and non-electrical systems • Cabin electrical systems and lights • Cabin electronics, communication-, information- and IFE-systems • Cabin and passenger process chains • RFID Aircraft Parts Marking • Energy sources and energy conversion
Literature	<ul> <li>Skript zur Vorlesung</li> <li>Jenkinson, L.R., Simpkin, P., Rhodes, D.: Civil Jet Aircraft Design. London: Arnold, 1999</li> <li>Rossow, CC., Wolf, K., Horst, P. (Hrsg.): Handbuch der Luftfahrzeugtechnik. Carl Hanser Verlag, 2014</li> <li>Moir, I., Seabridge, A.: Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, Wiley 2008</li> <li>Davies, M.: The standard handbook for aeronautical and astronautical engineers. McGraw-Hill, 2003</li> <li>Kompendium der Flugmedizin. Verbesserte und ergänzte Neuauflage, Nachdruck April 2006. Fürstenfeldbruck, 2006</li> <li>Campbell, F.C.: Manufacturing Technology for Aerospace Structural Materials. Elsevier Ltd., 2006</li> </ul>

Course L1546: Aircraft Cabin Systems		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses							
<b>Title</b> Avionics of Safty Critic	al Svst	ems (L1640)		<b>Typ</b> Lecture		Hrs/wk	<b>CP</b> 3
Avionics of Safty Critic	-			Recitation	Section	1	1
Avionics of Safty Critic	-			(small) Practical Cour	se	1	2
Module Responsible		artin Halle					
Admission Requirements	None						
Recommended Previous Knowledge	•	knowledge Mathemat Electrical E Informatic	ics Engineering				
Educational Objectives	After	taking part	successfully, s	tudents have reached t	he follo	wing learn	ing resul
Professional Competence		ents can:					
Knowledge	•	avionics denote pro depict the can compa	ocesses and sta principles of Ir are hardware a	ortant principles and or andards of safety-critica stegrated Modular Avior nd bus systems used in developing a safety-crit	al softwa nics (IMA n avionic	are develo A) ss	pment
Skills	•	program A plan avion	.653 application ics architecture	are and simulations ns es up to a certain exter ssess test results	nd		
Personal Competence	Stude	ents can:					
Social Competence	•	jointly dev exchange	information for	in inhomogeneous tean mally with other teams ults in a convenient wa	5		
Autonomy	•			ents for an avionics sys cepts for systems base		fety-critica	al avionic

Credit points	6	
Course	CompulsorBonus  Yes None	Form Description Subject theoretical and
achievement	res None	practical work
Examination	Oral exam	
Examination duration and scale	30 min	
the Following	Elective Compulsory Aircraft Systems Engin Aircraft Systems Engin Aircraft Systems Engin Theoretical Mechanica Compulsory	g: Specialisation Control and Power Systems Engineering: neering: Specialisation Aircraft Systems: Elective Compulsory neering: Specialisation Cabin Systems: Elective Compulsory neering: Specialisation Avionic Systems: Compulsory al Engineering: Technical Complementary Course: Elective al Engineering: Specialisation Aircraft Systems Engineering:

Course L1640: Avionics of Safty Critical Systems		
Тур	Lecture	
Hrs/wk		
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Martin Halle	
Language	DE	
Cycle	WiSe	
	Avionics are all kinds off flight electronics. Today there is no aircraft system function without avionics, and avionics are one main source of innovation in aerospace industry. Since many system functions are highly safety critical, the development of avionics hardware and software underlies mandatory constraints, technics, and processes. It is inevitable for system developers and computer engineers in aerospace industry to understand and master these. This lecture teaches the risks and techniques of developing safety critical hardware and software; major avionics components; integration; and test with a practical orientation. A focus is on Integrated Modular Avionics (IMA). The lecture is accompanied by a mandatory and laboratory exercises.	
Content		
Literature	<ul> <li>Moir, I.; Seabridge, A. &amp; Jukes, M., Civil Avionics Systems Civil Avionics Systems, John Wiley &amp; Sons, Ltd, 2013</li> <li>Spitzer, C. R. Spitzer, Digital Avionics Handbook, CRC Press, 2007</li> <li>FAA, Advanced Avionics Handbook U.S. Department of Transportation Federa Aviation Administration, 2009</li> <li>Moir, I. &amp; Seabridge, A. Aircraft Systems, Wiley, 2008, 3</li> </ul>	

Course L1641: Avionics of Safty Critical Systems		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Martin Halle	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1652: Avionics of Safty Critical Systems		
Тур	Practical Course	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Dr. Martin Halle	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

•				
Courses				
<b>Title</b> Fatigue & Damage Tolerance (L0310)		<b>Typ</b> Lecture	Hrs/w 2	<b>/k CP</b> 3
		Project-/probler	m-	
Lightweight Design Practical Course (L1258)		based Learning	3	3
Aviation Security (L1549)		Lecture Recitation	2 Section <sub>1</sub>	2
Aviation Security (L1550)		(small)	1	1
Mechanisms, Systems and Processes of Materials Testing (L0950)		Lecture 	2	2
Turbo Jet Engines (L09	of Fibre Reinforced Composites (L1514)	Lecture	2 2	3
System Simulation (L1		Lecture Lecture	2	3 2
			Section 1	
System Simulation (L1821)		(large)	1	2
Materials Testing (L0949)		Lecture	2	2
Reliability in Engineering Dynamics (L0176)		Lecture	2	2
Reliability in Engineering Dynamics (L1303)		Recitation (small)	Section 1	2
Reliability of avionics assemblies (L1554)		Lecture	2	2
Reliability of avionics assemblies (L1555)		Recitation (small)	Section 1	1
Reliability of Aircraft S	ystems (L0749)	Lecture	2	3
Module	l			
Responsible	IProf Frank Injelecke			
Admission	INone			
Requirements	Basic knowledge in:			
Recommended Previous Knowledge	<ul> <li>Thermodynamics</li> </ul>			
Educational Objectives	After taking part successfully, students l	have reached th	e following le	earning results
Professional				
Competence				
Knowledge	<ul> <li>Students are able to find their way through selected special areas withir systems engineering, air transportation system and material science</li> <li>Students are able to explain basic models and procedures in selected specia areas.</li> <li>Students are able to interrelate scientific and technical knowledge.</li> </ul>			
Skills	Students are able to apply basic method	ls in selected ar	eas of engine	ering.
Personal				
Competence				
Social Competence				
	Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.			
Autonomy			circy want to	o deepen the
				o deepen the
	knowledge and skills through the election  Depends on choice of courses		ency want to	o deepen the

	Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory
Assignment for	Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory
	International Management and Engineering: Specialisation II. Aviation Systems:
	Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering:
	Elective Compulsory

Course L0310: Fatigue & Damage Tolerance	
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
Literature	Jaap Schijve, Fatigue of Structures and Materials. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989

Course L1258: Ligh	ntweight Design Practical Course
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	30 min
	Prof. Dieter Krause
Language	
Cycle	
Content	<ul> <li>Development of a sandwich structure made of fibre reinforced plastics</li> <li>getting familiar with fibre reinforced plastics as well as lightweight design</li> <li>Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA)</li> <li>Determination of material properties based on sample tests</li> <li>manufacturing of the structure in the composite lab</li> <li>Testing of the developed structure</li> <li>Concept presentation</li> <li>Self-organised teamwork</li> </ul>
Literature	<ul> <li>Schürmann, H., "Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, 2005.</li> <li>Puck, A., "Festigkeitsanalsyse von Faser-Matrix-Laminaten", Hanser, München, Wien, 1996.</li> <li>R&amp;G, "Handbuch Faserverbundwerkstoffe", Waldenbuch, 2009.</li> <li>VDI 2014 "Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund"</li> <li>Ehrenstein, G. W., "Faserverbundkunststoffe", Hanser, München, 2006.</li> <li>Klein, B., "Leichtbau-Konstruktion", Vieweg &amp; Sohn, Braunschweig, 1989.</li> <li>Wiedemann, J., "Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, 1986.</li> <li>Wiedemann, J., "Leichtbau Band 2: Konstruktion", Springer, Berlin, Heidelberg, 1986.</li> <li>Backmann, B.F., "Composite Structures, Design, Safety and Innovation", Oxford (UK), Elsevier, 2005.</li> <li>Krause, D., "Leichtbau", In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012.</li> <li>Schulte, K., Fiedler, B., "Structure and Properties of Composite Materials", Hamburg, TUHH - TuTech Innovation GmbH, 2005.</li> </ul>

Course L1549: Aviation Security	
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization.  The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization:  • Historical development  • The special role of air transport  • Motive and attack vectors  • The human factor  • Threats and risk  • Regulations and law  • Organization and implementation of aviation security tasks  • Passenger and baggage checks  • Cargo screening and secure supply chain  • Safety technologies
Literature	<ul> <li>Skript zur Vorlesung</li> <li>Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011</li> <li>Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008</li> </ul>

Course L1550: Aviation Security	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization.  The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization:  • Historical development  • The special role of air transport  • Motive and attack vectors  • The human factor  • Threats and risk  • Regulations and law  • Organization and implementation of aviation security tasks  • Passenger and baggage checks  • Cargo screening and secure supply chain  • Safety technologies
Literature	<ul> <li>Skript zur Vorlesung</li> <li>Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011</li> <li>Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008</li> </ul>

Course L0950: Mechanisms, Systems and Processes of Materials Testing	
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
Examination duration and scale	
Lecturer	Dr. Jan Oke Peters
Language	DE
Cycle	SoSe
Content	Application, analysis and discussion of basic and advanced testing methods to ensure correct selection of applicable testing procedure for investigation of part/materials deficiencies  Stress-strain relationships Strain gauge application Visko elastic behavior Tensile test (strain hardening, necking, strain rate) Compression test, bending test, torsion test Crack growth upon static loading (J-Integral) Crack growth upon cyclic loading (micro- und macro cracks) Effect of notches Creep testing (physical creep test, influence of stress and temperature, Larson Miller parameter) Wear testing Non destructive testing application for overhaul of jet engines
Literature	<ul> <li>E. Macherauch: Praktikum in Werkstoffkunde, Vieweg</li> <li>G. E. Dieter: Mechanical Metallurgy, McGraw-Hill</li> <li>R. Bürgel: Lehr- und Übungsbuch Festigkeitslehre, Vieweg</li> <li>R. Bürgel: Werkstoffe sícher beurteilen und richtig einsetzen, Vieweg</li> </ul>

Course L0908: Turbo Jet Engines	
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	
Lecturer	Dr. Burkhard Andrich
Language	DE
Cycle	WiSe
Content	<ul> <li>Cycle of the gas turbine</li> <li>Thermodynamics of gas turbine components</li> <li>Wing-, grid- and stage-sizing</li> <li>Operating characteristics of gas turbine components</li> <li>Sizing criteria's for jet engines</li> <li>Development trends of gas turbines and jet engines</li> <li>Maintenance of jet engines</li> </ul>
Literature	<ul> <li>Bräunling: Flugzeugtriebwerke</li> <li>Engmann: Technologie des Fliegens</li> <li>Kerrebrock: Aircraft Engines and Gas Turbines</li> </ul>

Course L1514: Stru	ctural Mechanics of Fibre Reinforced Composites
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	WiSe
	Classical laminate theory
	Rules of mixture
	Failure mechanisms and criteria of composites
	Boundary value problems of isotropic and anisotropic shells
Content	Stability of composite structures
	Optimization of laminated composites
	Modelling composites in FEM
	Numerical multiscale analysis of textile composites
	Progressive failure analysis
Literature	<ul> <li>Schürmann, H., "Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage.</li> <li>Wiedemann, J., "Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, aktuelle Auflage.</li> <li>Reddy, J.N., "Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition.</li> <li>Jones, R.M., "Mechanics of Composite Materials", Scripta Book Co., Washington, current edition.</li> <li>Timoshenko, S.P., Gere, J.M., "Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition.</li> <li>Turvey, G.J., Marshall, I.H., "Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition.</li> <li>Herakovich, C.T., "Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition.</li> <li>Mittelstedt, C., Becker, W., "Strukturmechanik ebener Laminate", aktuelle Auflage.</li> </ul>

Course L1820: System Simulation	
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.  • Instruction and modelling of physical processes • Modelling and limits of model • Time constant, stiffness, stability, step size • Terms of object orientated programming • Differential equations of simple systems • Introduction into Modelica • Introduction into simulation tool • Example: Hydraulic systems and heat transfer • Example: System with different subsystems
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</li> <li>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</li> <li>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</li> </ul>

Course L1821: System Simulation	
Тур	Recitation Section (large)
Hrs/wk	1
СР	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0949:	: Materials Testing
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Jan Oke Peters
Language	DE
Cycle	WiSe
Content	Application and analysis of basic mechanical as well as non-destructive testing of materials  • Determination elastic constants • Tensile test • Fatigue test (testing with constant stress, strain, or plastiv strain amplitude, low and high cycle fatigue, mean stress effect) • Crack growth upon static loading (stress intensity factor, fracture toughness) • Creep test • Hardness test • Charpy impact test • Non destructive testing
Literature	E. Macherauch: Praktikum in Werkstoffkunde, Vieweg G. E. Dieter: Mechanical Metallurgy, McGraw-Hill

Course L0176: Reliability in Engineering Dynamics	
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
Examination duration and scale	
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	<ul> <li>Method for calculation and testing of reliability of dynamic machine systems</li> <li>Modeling</li> <li>System identification</li> <li>Simulation</li> <li>Processing of measurement data</li> <li>Damage accumulation</li> <li>Test planning and execution</li> </ul>
Literature	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4  Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737  Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936.  VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412

Course L1303: Reliability in Engineering Dynamics		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
<b>Examination Form</b>	Klausur	
Examination duration and scale		
Lecturer	Prof. Uwe Weltin	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1554: Reli	ability of avionics assemblies
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
Examination duration and scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:  • Survey of the role of electronics in aviation  • System levels: From silicon to mechatronic systems  • Semiconductor components, assemblies, systems  • Challenges of electronic packaging technology (AVT)  • System integration in electronics: Requirements for AVT  • Methods and techniques of AVT  • Error patterns for assemblies and avoidance of errors  • Reliability analysis for printed circuit boards (PCBs)  • Reliability of Avionics  • COTS, ROTS, MOTS and the F <sup>3</sup> I concept  • Future challenges for electronics
Literature	- Skript zur Vorlesung  Hanke, HJ.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994  Scheel, W.: Baugruppentechnologie der Elektronik.  Montage. Verlag Technik, 1999

Course L1555: Reliability of avionics assemblies		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
<b>Examination Form</b>	Klausur	
Examination duration and scale		
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:  • Survey of the role of electronics in aviation • System levels: From silicon to mechatronic systems • Semiconductor components, assemblies, systems • Challenges of electronic packaging technology (AVT) • System integration in electronics: Requirements for AVT • Methods and techniques of AVT • Error patterns for assemblies and avoidance of errors • Reliability analysis for printed circuit boards (PCBs) • Reliability of Avionics • COTS, ROTS, MOTS and the F <sup>3</sup> I concept • Future challenges for electronics	
Literature	- Skript zur Vorlesung Hanke, HJ.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999	

Course L0749: Reliability of Aircraft Systems			
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
<b>Examination Form</b>	Klausur		
Examination duration and scale			
Lecturer	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>Functions of reliability and safety (regulations, certification requirements)</li> <li>Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment)</li> <li>Reliability analysis of electrical and mechanical systems</li> </ul>		
Literature	<ul> <li>CS 25.1309</li> <li>SAE ARP 4754</li> <li>SAE ARP 4761</li> </ul>		

Module M1193	3: Cabin Systems Engineerin	ıg		
Courses				
Title		Тур	Hrs/wk	СР
	nication technology in cabin electronics and	Lecture	2	2
avionics (L1557)  Computer and commun	nication technology in cabin electronics and	Recitation Section	n .	
avionics (L1558)	median eccimology in easily electronics and	(small)	1	1
Model-Based Systems	Engineering (MBSE) with SysML/UML (L1551)	Project-/problem- based Learning	3	3
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
	Basic knowledge in:			
	Mathematics     Machanics			
D	<ul><li>Mechanics</li><li>Thermodynamics</li></ul>			
Recommended Previous	Electrical Engineering			
Knowledge	Control Systems			
	Previous knowledge in:			
	Systems Engineering			
Educational	After taking part successfully, students h	ave reached the follo	wing learn	ing results
Objectives	——————————————————————————————————————	ave reactied the follo	wing lean	ing results
Professional				
Competence	Students are able to:			
Knowledge	<ul> <li>describe the structure and operation of computer architectures</li> <li>explain the structure and operation of digital communication Networks</li> <li>explain architectures of cabin electronics, integrated modular avionics (IMA) and Aircraft Data Communication Network (ADCN)</li> <li>understand the approach of Model-Based Systems Engineering (MBSE) in the design of hardware and software-based cabin systems</li> </ul>			
Skills	Students are able to:  • understand, operate and maintain a Minicomputer  • build up a network communication and communicate with other network participants  • connect a minicomputer with a cabin management system (A380 CIDS) and communicate over a AFDX®-Network  • model system functions by means of formal languages SysML/UML and generate software code from the models  • execute software code on a minicomputer			
Personal Competence				
Social Competence	Students are able to: • elaborate partial results and merge wit	h others to form a cor	mplete sol	ution
Autonomy	Students are able to: • organize and schedule their practical ta	asks		
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			

Examination duration and scale	120 minutes
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory

Course L1557: Com	nputer and communication technology in cabin electronics and avionics		
Тур	Lecture		
Hrs/wk	2		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Ralf God		
Language	DE		
Cycle	WiSe		
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge of computer and communication technology in electronic systems in the cabin and in aircraft. For the system engineer the strong interaction of software, mechanical and electronic system components nowadays requires a basic understanding of cabin electronics and avionics.  The course teaches the basics of design and functionality of computers and data networks. Subsequently it focuses on current principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronics and cabin networks:  History of computer and network technology  Layer model in computer technology  Computer architectures (PC, IPC, Embedded Systems)  BIOS, UEFI and operating system (OS)  Programming languages (machine code and high-level languages)  Applications and Application Programming Interfaces  External interfaces (serial, USB, Ethernet)  Layer model in network technology  Network topologies  Network topologies  Network components  Bus access procedures  Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN)  Cabin electronics and cabin networks		
Literature	- Skript zur Vorlesung - Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 - Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004 - Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006		

Course L1558: Com	nputer and communication technology in cabin electronics and avionics
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge of computer and communication technology in electronic systems in the cabin and in aircraft. For the system engineer the strong interaction of software, mechanical and electronic system components nowadays requires a basic understanding of cabin electronics and avionics.  The course teaches the basics of design and functionality of computers and data networks. Subsequently it focuses on current principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronics and cabin networks:  History of computer and network technology  Computer architectures (PC, IPC, Embedded Systems)  BIOS, UEFI and operating system (OS)  Programming languages (machine code and high-level languages)  Applications and Application Programming Interfaces  External interfaces (serial, USB, Ethernet)  Layer model in network technology  Network topologies  Network components  Bus access procedures  Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN)  Cabin electronics and cabin networks
Literature	- Skript zur Vorlesung - Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 - Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004 - Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006

Course L1551: Mod	lel-Based Systems Engineering (MBSE) with SysML/UML
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal languages SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Based Systems Engineering (MBSE) on a realistic hardware platform (e.g. Arduino®, Raspberry Pi®):  • What is a model?  • What is Systems Engineering?  • Survey of MBSE methodologies  • The modelling languages SysML /UML  • Tools for MBSE  • Best practices for MBSE  • Requirements specification, functional architecture, specification of a solution  • From model to software code  • Validation and verification: XiL methods  • Accompanying MBSE project
Literature	<ul> <li>Skript zur Vorlesung</li> <li>Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design.</li> <li>Auflage, dpunkt.Verlag, 2008</li> <li>Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering &amp; Tech, 2011</li> </ul>

## **Specialization Maritime Technology**

At the center of the specialization Maritime Techniques lies the acquisition of knowledge and skills to develop, calculate and evaluate shipboard and offshore structures and their components. This is done in modules on the topics of marine engine systems, marine auxiliary systems, ship vibrations, maritime technology and maritime systems, port construction and port planning, port logistics, maritime transport and marine geotechnics and numerics in electives. In addition, subjects in the Technical Supplement Course for TMBMS (according FSPO) are freely selectable.

Courses				
Γitle		Тур	Hrs/wk	СР
Electrical Installation o	n Ships (L1531)	Lecture Recitation	2 Soction	2
Electrical Installation o	n Ships (L1532)	(large)	Section 1	1
Auxiliary Systems on B	Board of Ships (L1249)	Lecture Recitation	2 Saction	2
Auxiliary Systems on E	Board of Ships (L1250)	(large)	Section 1	1
Module Responsible	Prof. Christopher Friedrich Wirz			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stude	nts have reached	the following learn	ing results
Professional Competence				
Knowledge	<ul> <li>name the operating behaviour of consumers,</li> <li>describe special requirements on the design of supply networks and to the electrical equipment in isolated networks, as e.g. onboard ships, offshore units, factories and emergency power supply systems,</li> <li>explain power generation and distribution in isolated grids, wave generator systems on ships,</li> <li>name requirements for network protection, selectivity and operational monitoring,</li> <li>name the requirements regarding marine equipment and apply to product development, as well as</li> <li>describe operating procedures of equipment components of standard and specialized ships and derive requirements for product development.</li> </ul>			
	Students are able to			
	calculate short-circuit currents, sw	itchgear,		
Skills	• design electrical propulsion systems for ships			
	design additional machinery comp	onents, as well as	S	
	• to apply basic principles of hydrau	lics and to develo	p hydraulic system	ıs.
Personal Competence				
	The students are able to communication	ate and cooperate	e in a professional	environme

Social Competence	in the shipbuilding and component supply industry.			
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	20 min			
the Following	Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory			

Course L1531: Electrical Installation on Ships		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Günter Ackermann	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>performance in service of electrical consumers.</li> <li>special requirements for power supply systems and for electrical equipment in isolated systems/networks e. g. aboard ships, offshore installations, factory systems and emergency power supply systems.</li> <li>power generation and distribution in isolated networks, shaft generators for ships</li> <li>calculation of short circuits and behaviour of switching devices</li> <li>protective devices, selectivity monitoring</li> <li>electrical Propulsion plants for ships</li> </ul>	
Literature	H. Meier-Peter, F. Bernhardt u. a.: Handbuch der Schiffsbetriebstechnik, Seehafen Verlag (engl. Version: "Compendium Marine Engineering") Gleß, Thamm: Schiffselektrotechnik, VEB Verlag Technik Berlin	

Course L1532: Electrical Installation on Ships		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Günter Ackermann	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1249: Auxiliary Systems on Board of Ships		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Christopher Friedrich Wirz	
Language	DE	
Cycle	SoSe	
Content	<ul> <li>Vorschriften zur Schiffsausrüstung</li> <li>Ausrüstungsanlagen auf Standard-Schiffen</li> <li>Ausrüstungsanlagen auf Spezial-Schiffen</li> <li>Grundlagen und Systemtechnik der Hydraulik</li> <li>Auslegung und Betrieb von Ausrüstungsanlagen</li> </ul>	
Literature	<ul> <li>H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik</li> <li>H. Watter: Hydraulik und Pneumatik</li> </ul>	

Course L1250: Auxiliary Systems on Board of Ships		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Christopher Friedrich Wirz	
Language	DE	
Cycle	SoSe	
Content		
	Siehe korrespondierende Vorlesung	
Literature		

Module M117	7: Maritime Techno	logy and	Maritim	e Syst	ems	
Courses						
Title	vistams (1,0069)		<b>Typ</b> Lecture		Hrs/wk	<b>CP</b> 2
Analysis of Maritime S			Recitation	Section	_	
Analysis of Maritime S	-		(small)		_	1
	ne Technology (L0070)		Lecture Recitation	Section	2	2
Introduction to Maritim	ne Technology (L1614)		(small)		1	1
Module Responsible	I Prof Midlictata Maddi-Maked	ud				
Admission Requirements	LNODE					
Recommended Previous Knowledge	Solid knowledge and competences in mechanics, fluid dynamics and analysis (series, periodic functions, continuity, differentiability, integration, multiple variables, ordinaray and partial differential equations, boundary value problems, initial conditions and eigenvalue problems).					
Educational Objectives		ly, students h	ave reached	the follo	wing learn	ing results
Professional						
Competence	<b>;</b>	6.11				
Knowledge	After successful completion of this class, students should have an overview about phenomena and methods in ocean engineering and the ability to apply and extend the methods presented.  In detail, the students should be able to  • describe the different aspects and topics in Maritime Technology, • apply existing methods to problems in Maritime Technology, • discuss limitations in present day approaches and perspectives in the future, • Techniques for the analysis of offshore systems, • Modeling and evaluation of dynamic systems, • System-oriented thinking, decomposition of complex systems.					
Skills	The students learn the ability of apply and transfer existing methods and techniques on novel questions in maritime technologies. Furthermore, limits of the existing knowledge and future developments will be discussed.					
Personal						
Competence Social Competence	The processing of an exercise in a group of up to four students shall strengthen the communication and team-working skills and thus promote an important working technique of subsequent working days. The collaboration has to be illustrated in a					
Autonomy	The course contents are absorbed in an exercise work in a group and individually checked in a final exam in which a self-reflection of the learned is expected without tools.					
Workload in Hours	Independent Study Time 96	Independent Study Time 96, Study Time in Lecture 84				
Credit points	6					
Course achievement	LINONE			_		
	Written exam					
Examination						

I	duration and	
	scale	
		Naval Architecture and Ocean Engineering: Core qualification: Compulsory
	Assignment for	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	the Following	
	Curricula	Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective
		Compulsory

Course L0068: Analysis of Maritime Systems			
Тур	Lecture		
Hrs/wk	2		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Moustafa Abdel-Maksoud, Dr. Alexander Mitzlaff		
Language	DE		
Cycle	SoSe		
Content	<ol> <li>Hydrostatic analysis         <ul> <li>Buoyancy,</li> <li>Stability,</li> </ul> </li> <li>Hydrodynamic analysis         <ul> <li>Froude-Krylov force</li> <li>Morison's equation,</li> <li>Radiation and diffraction</li> <li>transparent/compact structures</li> </ul> </li> <li>Evaluation of offshore structures: Reliability techniques (security, reliability, disposability)         <ul> <li>Short-term statistics</li> <li>Long-term statistics and extreme events</li> </ul> </li> </ol>		
Literature	<ul> <li>G. Clauss, E. Lehmann, C. Östergaard. Offshore Structures Volume I: Conceptual Design and Hydrodynamics. Springer Verlag Berlin, 1992</li> <li>E. V. Lewis (Editor), Principles of Naval Architecture ,SNAME, 1988</li> <li>Journal of Offshore Mechanics and Arctic Engineering</li> <li>Proceedings of International Conference on Offshore Mechanics and Arctic Engineering</li> <li>S. Chakrabarti (Ed.), Handbook of Offshore Engineering, Volumes 1-2, Elsevier, 2005</li> <li>S. K. Chakrabarti, Hydrodynamics of Offshore Structures, WIT Press, 2001</li> </ul>		

Course L0069: Analysis of Maritime Systems	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Moustafa Abdel-Maksoud, Dr. Alexander Mitzlaff
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0070: Intr	oduction to Maritime Technology
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Sven Hoog
Language	DE
Cycle	WiSe
Content	<ol> <li>Introduction         <ul> <li>Ocean Engineering and Marine Research</li> <li>The potentials of the seas</li> <li>Industries and occupational structures</li> </ul> </li> <li>Coastal and offshore Environmental Conditions         <ul> <li>Physical and chemical properties of sea water and sea ice</li> <li>Flows, waves, wind, ice</li> <li>Biosphere</li> </ul> </li> <li>Response behavior of Technical Structures</li> <li>Maritime Systems and Technologies         <ul> <li>General Design and Installation of Offshore-Structures</li> <li>Geophysical and Geotechnical Aspects</li> <li>Fixed and Floating Platforms</li> <li>Mooring Systems, Risers, Pipelines</li> <li>Energy conversion: Wind, Waves, Tides</li> <li>Tides</li> <li>Energy conversion: Wind, Waves, Tides</li> <li>Tides</li> <li>Tides</li></ul></li></ol>
Literature	<ul> <li>Chakrabarti, S., Handbook of Offshore Engineering, vol. I/II, Elsevier 2005.</li> <li>Gerwick, B.C., Construction of Marine and Offshore Structures, CRC-Press 1999.</li> <li>Wagner, P., Meerestechnik, Ernst&amp;Sohn 1990.</li> <li>Clauss, G., Meerestechnische Konstruktionen, Springer 1988.</li> <li>Knauss, J.A., Introduction to Physical Oceanography, Waveland 2005.</li> <li>Wright, J. et al., Waves, Tides and Shallow-Water Processes, Butterworth 2006.</li> <li>Faltinsen, O.M., Sea Loads on Ships and Offshore Structures, Cambridge 1999.</li> </ul>

Course L1614: Introduction to Maritime Technology		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Sven Hoog	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1240	D: Fatigue Strength of S	hips and	Offsl	nore :	Structi	ures
Courses						
<b>Title</b> Fatigue Strength of Sh	ips and Offshore Structures (L1521)	<b>Typ</b> Lectur	re		Hrs/wk 2	<b>CP</b> 3
Fatigue Strength of Sh	ips and Offshore Structures (L1522)	Recita (small		Section	2	3
Module Responsible	Prof. Sören Ehlers					
Admission Requirements	None					
	Structural analysis of ships and/or offshore structures and fundamental knowledge in mechanics and mechanics of materials					
Educational Objectives	After taking part successfully, stud	ents have re	ached th	ne follov	wing learn	ing results
Professional Competence						
-	Students are able to					
Knowledge	<ul> <li>describe fatigue loads and stresses, as well as</li> <li>describe structural behaviour under cyclic loads.</li> </ul>					
Skills	Students are able to calculate life prediction based on the S-N approach as well as life prediction based on the crack propagation.					
Personal Competence						
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.					
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.					
<b>Workload in Hours</b>	Independent Study Time 124, Stud	y Time in Le	cture 56	i		
Credit points	6					
Course achievement	None					
Examination	Oral exam					
Examination duration and scale						
Assignment for the Following Curricula	Compulsory					

Course L1521: Fatigue Strength of Ships and Offshore Structures		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Wolfgang Fricke	
Language	EN	
Cycle	WiSe	
Content	1.) Introduction 2.) Fatigue loads and stresses 3.) Structural behaviour under cyclic loads - Structural behaviour under constant amplitude loading - Influence factors on fatigue strength - Material behaviour under contant amplitude loading - Special aspects of welded joints - Structural behaviour under variable amplitude loading 4.) Life prediction based on the S-N approach - Damage accumulation hypotheses - nominal stress approach - structural stress approach - notch stress approach - notch stress approach - numerical analyses 5.) Life prediction based on the crack propagation - basic relationships in fracture mechanics - description of crack propagation - numerical analysis - safety against unstable fracture	
Literature	Siehe Vorlesungsskript	

Course L1522: Fatigue Strength of Ships and Offshore Structures		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Wolfgang Fricke	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M066	3: Marine Geotechnics			
Courses				
Title		Тур	Hrs/wk	СР
Marine Geotechnics (L	0548)	Lecture	1 Costion	2
Marine Geotechnics (L	0549)	Recitation (large)	Section 2	2
Steel Structures in Fou	undation and Hydraulic Engineering (L1146)	Lecture	2	2
Module Responsible	i Prof. Illroen Grane			
Admission Requirements	None			
Recommended Previous Knowledge	Leaureaci Cail Inharatary courca	hematics I-III		
Educational Objectives	LATTER TAKING NART CHCCECCTIIIIV CTHGENTC R	nave reached	the following learr	ning results
Professional Competence Knowledge Skills				
Personal Competence Social Competence				
Autonomy	<b>i</b>			
Workload in Hours	Independent Study Time 110, Study Tim	e in Lecture 7	0	
Credit points	6			
Course achievement	INODA			
Examination	Written exam			
Examination duration and scale	90 min			
	Civil Engineering: Specialisation Geotech Civil Engineering: Specialisation Structur Civil Engineering: Specialisation Coastal Theoretical Mechanical Engineering: Specialisation Compulsory Theoretical Mechanical Engineering: Tompulsory Water and Environmental Engineering: Specialisation Water and Environmental Engineering: Specialisation	ral Engineering Engineering: Decialisation I echnical Com Specialisation ng: Specialis	g: Elective Compu Compulsory Maritime Technolo aplementary Cour Cities: Elective Co ation Environme	gy: Elective se: Elective mpulsory nt: Elective

Course L0548: Marine Geotechnics		
Тур	Lecture	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Jürgen Grabe	
Language	DE	
Cycle	SoSe	
Content	<ul> <li>Geotechnical investigation an description of the seabed</li> <li>Foundations of Offshore-Constructions</li> <li>cCliff erosion</li> <li>Sea dikes</li> <li>Port structures</li> <li>Flood protection structures</li> </ul>	
Literature	<ul> <li>EAK (2002): Empfehlungen für Küstenschutzbauwerke</li> <li>EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke</li> <li>Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London</li> <li>Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst &amp; Sohn, Berlin</li> </ul>	

Course L0549: Marine Geotechnics		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Jürgen Grabe	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1146: Steel Structures in Foundation and Hydraulic Engineering		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Frank Feindt	
Language	DE	
Cycle		
Content	Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue	
Literature	EAU 2012, EA-Pfähle, EAB	

Module M1132	2: Maritime Transport			
Courses				
<b>Title</b> Maritime Transport (LC		<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3
Module Responsible	Prof. Carlos Jahn	(Sman)		
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, studer	nts have reached t	he following learn	ing results
Professional Competence				
Knowledge	<ul> <li>present the actors involved in their typical tasks;</li> <li>name common cargo types corresponding categories;</li> <li>explain operating forms in management in transport networking the advantages and distransport and apply them in posteroid present relevant factors for terminals and discuss them in estimate the potential of digiting their present relevant and discuss them in the potential of digiting their present relevant factors.</li> </ul>	maritime shipp maritime shipp works; sadvantages of the ractice; the location pla a problem-oriente	and classify cal oing, transport of e various modes of anning of ports a ed way;	rgo to the options and of hinterland
Skills	<ul> <li>determine the mode of trans maritime supply chain;</li> <li>identify possible cost drivers in proposals for cost reduction;</li> <li>record, map and systematica maritime logistics chain, is solutions;</li> <li>perform risk assessments of heanalyse accidents in the fier relevance in everyday life;</li> <li>deal with current research differentiated way;</li> <li>apply different process mode activity and to work out the research of the study of the search of the searc</li></ul>	n a transport chain Ily analyse mater dentify possible uman disruptions Id of maritime lo topics in the fiel	n and recommend ial and information problems and to the supply chapgistics and evaluated of maritime local and itherto unknown.	appropriate on flows of a recommend in; uating their ogistics in a
Personal Competence	The students are able to			
Social Competence	<ul><li>discuss and organise extensiv</li><li>document and present the ela</li></ul>		n groups;	
	The students are capable to  • research and select technical	litoraturo includir	ia standards and s	quidelines

Autonomy	<ul> <li>submit own shares in an extensive written elaboration in small groups in due time.</li> </ul>		
Workload in Hours	Independent Study Tim	e 124, Study Time in Le	ecture 56
Credit points	6		
	Compulsor <b>B</b> onus	Form	Description
Course achievement		Subject theoretical practical work	and Teilnahme an einem Planspiel und anschließende schriftliche Ausarbeitung
Examination	Written exam		
Examination duration and scale			
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		

Course L0063: Mar	itime Transport
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
	The general tasks of maritime logistics include the planning, design, implementation and control of material and information flows in the logistics chain ship - port - hinterland. This includes technology assessment, selection, dimensioning and implementation as well as the operation of technologies.
Content	The aim of the course is to provide students with knowledge of maritime transport and the actors involved in the maritime transport chain. Typical problem areas and tasks will be dealt with, taking into account the economic development. Thus, classical problems as well as current developments and trends in the field of maritime logistics are considered.
	In the lecture, the components of the maritime logistics chain and the actors involved will be examined and risk assessments of human disturbances on the supply chain will be developed. In addition, students learn to estimate the potential of digitisation in maritime shipping, especially with regard to the monitoring of ships. Further content of the lecture is the different modes of transport in the hinterland, which students can evaluate after completion of the course regarding their advantages and disadvantages.
Literature	<ul> <li>Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005.</li> <li>Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009.</li> <li>Stopford, Martin. Maritime Economics Routledge, 2009</li> </ul>

Course L0064: Mar	itime Transport
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
Content	The exercise lesson bases on the haptic management game MARITIME. MARITIME focuses on providing knowledge about structures and processes in a maritime transport network. Furthermore, the management game systematically provides process management methodology and also promotes personal skills of the participants.
Literature	<ul> <li>Stopford, Martin. Maritime Economics Routledge, 2009</li> <li>Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005.</li> <li>Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009.</li> </ul>

Courses				
<b>Title</b> Port Logistics (L0686)		<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Port Logistics (L1473)		Recitation (small)	Section 2	3
Module Responsible	Prof. Carlos Jahn			
Admission Requirements	INONE			
Recommended Previous Knowledge	none			
Educational Objectives		nts have reached	the following lear	ning results
Professional				
Competence	e   Th			
Knowledge	<ul> <li>analyze common planning ta planning) at seaport termina methods and tools) to solve t</li> <li>identify future developments of innovative seaport termi manner.</li> </ul>	f seaports (in terninals, as well as trical context; nt types of seapo ipment technologisks (e.g. berth plats and develop suthese planning tast and trends regarnals and discuss	the relevant oper rt terminals and es, logistic function nning, stowage p itable approaches (s; ding the planning them in a prob	their specifonal areas); lanning, yar (in terms o
Skills	<ul> <li>After completing the module, students will be able to</li> <li>recognize functional areas in ports and seaport terminals;</li> <li>define and evaluate suitable operating systems for container terminals;</li> <li>perform static calculations with regard to given boundary conditions, e. required capacity (parking spaces, equipment requirements, quay whength, port access) on selected terminal types;</li> <li>reliably estimate which boundary conditions influence common logistic indicators in the static planning of selected terminal types and to whe extent.</li> </ul>			
Personal Competence		nts can		
Social Competence	<ul> <li>transfer the acquired knowled</li> <li>discuss and successfully orga</li> <li>in small groups, document w</li> </ul>	nize extensive tas	k packages in sm	all groups;

Autonomy	<ul> <li>After completing the module, the students are able to</li> <li>research and select specialist literature, including standards, guidelines and journal papers, and to develop the contents independently;</li> <li>submit own parts in an extensive written elaboration in small groups in due time and to present them jointly within a fixed time frame.</li> </ul>
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	CompulsorBonus Form Description No 15 % Written elaboration
Examination	Written exam
Examination duration and scale	120 minutes
the Following	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0686: Port	t Logistics
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
Content	Port Logistics deals with the planning, control, execution and monitoring of material flows and the associated information flows in the port system and its interfaces to numerous actors inside and outside the port area.  The extraordinary role of maritime transport in international trade requires very efficient ports. These must meet numerous requirements in terms of economy, speed, safety and the environment. Against this background, the lecture Port Logistics deals with the planning, control, execution and monitoring of material flows and the associated information flows in the port system and its interfaces to numerous actors inside and outside the port area. The aim of the lecture Port Logistics is to convey an understanding of structures and processes in ports. The focus will be on different types of terminals, their characteristical layouts and the technical equipment used as well as the ongoing digitization and interaction of the players involved.  In addition, renowned guest speakers from science and practice will be regularly invited to discuss some lecture-relevant topics from alternative perspectives.  The following contents will be conveyed in the lectures:  • Instruction of structures and processes in the port  • Planning, control, implementation and monitoring of material and information flows in the port  • Fundamentals of different terminals, characteristical layouts and the technica equipment used  • Handling of current issues in port logistics
Literature	<ul> <li>Alderton, Patrick (2013). Port Management and Operations.</li> <li>Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium.</li> <li>Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005.</li> <li>Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen.</li> <li>Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele.</li> <li>Jahn, Carlos; Saxe, Sebastian (Hg.). Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag, 2017.</li> <li>Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft</li> <li>Lun, Y.H.V. and Lai, KH. and Cheng, T.C.E. (2010). Shipping and Logistics Management.</li> <li>Woitschützke, Claus-Peter (2013). Verkehrsgeografie.</li> </ul>

Course L1473: Port	: Logistics
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
Content	The content of the exercise is the independent preparation of a scientific paper plus an accompanying presentation on a current topic of port logistics. The paper deals with current topics of port logistics. For example, the future challenges in sustainability and productivity of ports, the digital transformation of terminals and ports or the introduction of new regulations by the International Maritime Organization regarding the verified gross weight of containers. Due to the international orientation of the event, the paper is to be prepared in English.
Literature	<ul> <li>Alderton, Patrick (2013). Port Management and Operations.</li> <li>Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium.</li> <li>Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. (2005) Berlin Heidelberg: Springer-Verlag.</li> <li>Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen.</li> <li>Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele.</li> <li>Jahn, Carlos; Saxe, Sebastian (Hg.) (2017) Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag.</li> <li>Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft</li> <li>Lun, Y.H.V. and Lai, KH. and Cheng, T.C.E. (2010). Shipping and Logistics Management.</li> <li>Woitschützke, Claus-Peter (2013). Verkehrsgeografie.</li> </ul>

Courses				
Title		Тур	Hrs/wk	СР
Marine Diesel Engine F	Plants (L0637)	Lecture	3 Costian	4
Marine Diesel Engine F	Plants (L0638)	Recitation (large)	Section 1	2
Module Responsible	I Prof ( nristonnar Friadrich Wirz			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, studer	nts have reached	the following learn	ing results
Professional				
Competence				
Knowledge	<ul> <li>• explain different types four / two-stroke engines and assign types to giver engines,</li> <li>• name definitions and characteristics, as well as</li> <li>• elaborate on special features of the heavy oil operation, lubrication and cooling.</li> </ul>			
Skills	<ul> <li>• evaluate the interaction of ship, engine and propeller,</li> <li>• use relationships between gas exchange, flushing, air demand, charge injectand combustion for the design of systems,</li> <li>• design waste heat recovery, starting systems, controls, automation, foundated and design machinery spaces, and</li> <li>• apply evaluation methods for excited motor noise and vibration.</li> </ul>			
Personal Competence				
•	The students are able to communica in the shipbuilding and component s		in a professional o	environme
Autonomy	The widespread scope of gained situations in their future profession in			to hand
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 5	6	
Credit points	6			
Course achievement	INONE			
Examination	Oral exam			
Examination duration and scale				
Assignment for	Energy Systems: Specialisation Ener Energy Systems: Specialisation Mari Naval Architecture and Ocean Engine Theoretical Mechanical Engineering	ne Engineering: C eering: Core quali	ompulsory fication: Elective C	

Curricula	Compulsory	•					
	Theoretical	Mechanical	Engineering:	Specialisation	Maritime	Technology:	Elective
	Compulsory	•					

Course L0637: Mar	Course L0637: Marine Diesel Engine Plants		
Тур	Lecture		
Hrs/wk	3		
СР	4		
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	Prof. Christopher Friedrich Wirz		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>Historischer Überblick</li> <li>Bauarten von Vier- und Zweitaktmotoren als Schiffsmotoren</li> <li>Vergleichsprozesse, Definitionen, Kenndaten</li> <li>Zusammenwirken von Schiff, Motor und Propeller</li> <li>Ausgeführte Schiffsdieselmotoren</li> <li>Gaswechsel, Spülverfahren, Luftbedarf</li> <li>Aufladung von Schiffsdieselmotoren</li> <li>Einspritzung und Verbrennung</li> <li>Schwerölbetrieb</li> <li>Schmierung</li> <li>Kühlung</li> <li>Wärmebilanz</li> <li>Abwärmenutzung</li> <li>Anlassen und Umsteuern</li> <li>Regelung, Automatisierung, Überwachung</li> <li>Motorerregte Geräusche und Schwingungen</li> <li>Fundamentierung</li> <li>Gestaltung von Maschinenräumen</li> </ul>		
Literature	<ul> <li>D. Woodyard: Pounder's Marine Diesel Engines</li> <li>H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik</li> <li>K. Kuiken: Diesel Engines</li> <li>Mollenhauer, Tschöke: Handbuch Dieselmotoren</li> <li>Projektierungsunterlagen der Motorenhersteller</li> </ul>		

Course L0638: Marine Diesel Engine Plants		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Christopher Friedrich Wirz	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

## Module M1175: Special Topics of Ship Propulsionand Hydrodynamics of High Speed Water Vehicles

or mgn speed	water venicles			
Courses				
<b>Title</b> Hydrodynamics of High Special Topics of Ship	n Speed Water Vehicles (L1593) Propulsion (L1589)	<b>Typ</b> Lecture Lecture	<b>Hrs/wk</b> 3 3	<b>CP</b> 3 3
Module Responsible	Prof. Moustafa Abdel-Maksoud			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge on ship resistance	, ship propulsion and	l propeller theor	У
Educational Objectives	After taking part successfully, stude	ents have reached th	e following learr	ning results
Professional Competence				
Knowledge	<ul> <li>Understand present research questions in the field of ship propulsion</li> <li>Explain the present state of the art for the topics considered</li> <li>Apply given methodology to approach given problems</li> <li>Evaluate the limits of the present ship propulsion systems</li> <li>Identify possibilities to extend present methods and technologies</li> <li>Evaluate the feasibility of further developments</li> </ul>			
Skills	Students are able to • select and apply suitable computing and simulation methods to determine the hydrodynamic characteristics of ship propulsion systems • model the behavior of ship propulsion systems under different operation conditions by using simplified methods • evaluate critically the investigation results of experimental or numerical investigations			
Personal Competence				
Social Competence	<ul> <li>Students are able to</li> <li>solve problems in heterogen results</li> <li>share new knowledge with groups</li> </ul>		document the co	orresponding
Autonomy	Students are able to assess their kr	nowledge by means o	of exercises and	case studies
<b>Workload in Hours</b>	Independent Study Time 96, Study	Time in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
the Following	Naval Architecture and Ocean Engir Theoretical Mechanical Engineerir Compulsory Theoretical Mechanical Engineerin Compulsory	ng: Technical Compl	lementary Cour	se: Elective

Course L1593: Hyd	rodynamics of High Speed Water Vehicles
Тур	Lecture
Hrs/wk	3
СР	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	SoSe
Content	<ol> <li>Resistance components of different high speed water vehicles</li> <li>Propulsion units of high speed vehicles</li> <li>Waves resistance in shallow and deep water</li> <li>Surface effect ships (SES)</li> <li>Hydrofoil supported vehicles</li> <li>Semi-displacement vehicles</li> <li>Planning vehicles</li> <li>Slamming</li> <li>Manoeuvrability</li> </ol>
Literature	Faltinsen,O. M., Hydrodynamics of High-Speed Marine Vehicles, Cambridge University Press, UK, 2006

Course L1589: Spe	cial Topics of Ship Propulsion
Тур	Lecture
Hrs/wk	3
СР	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	SoSe
Content	<ol> <li>Propeller Geometry</li> <li>Cavitation</li> <li>Model Tests, Propeller-Hull Interaction</li> <li>Pressure Fluctuation / Vibration</li> <li>Potential Theory</li> <li>Propeller Design</li> <li>Controllable Pitch Propellers</li> <li>Ducted Propellers</li> <li>Podded Drives</li> <li>Water Jet Propulsion</li> <li>Voith-Schneider-Propulsors</li> </ol>
Literature	<ul> <li>Breslin, J., P., Andersen, P., Hydrodynamics of Ship Propellers, Cambridge Ocean Technology, Series 3,         Cambridge University Press, 1996.</li> <li>Lewis, V. E., ed., Principles of Naval Architecture, Volume II Resistance, Propulsion and Vibration,         SNAME, 1988.</li> <li>N. N., International Confrrence Waterjet 4, RINA London, 2004</li> <li>N. N., 1st International Conference on Technological Advances in Podded Propulsion, Newcastle, 2004</li> </ul>

	2: Technical Elective Course for TMBMS (according to ic Regulations)
Courses	
Title	Typ Hrs/wk CP
itesponsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
;	see FSPO
Personal Competence	
Social Competence	
Autonomy	see FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Module M1233	3: Numerical Methods i	n Ship Design		
Courses				
<b>Title</b> Numerical Methods in S Numerical Methods in S		<b>Typ</b> Lecture Project-/problem-	<b>Hrs/wk</b> 2 2	<b>CP</b> 4 2
		based Learning		
responsible	Prof. Stefan Krüger			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	I NTTAR TAVINA NART CIICCACCTIIIIV CTI	idents have reached the fol	lowing learn	ing results
Professional Competence <i>Knowledge</i>				
<i>Skills</i> Personal Competence				
Social Competence Autonomy				
Workload in Hours	Independent Study Time 124, Stu	udy Time in Lecture 56		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and scale				
the Following	Naval Architecture and Ocean En Theoretical Mechanical Enginee Compulsory Theoretical Mechanical Enginee Compulsory	ring: Technical Compleme	entary Cour	se: Elective

Course L1271: Numerical Methods in Ship Design		
Тур	Lecture	
Hrs/wk	2	
СР	4	
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28	
Lecturer	Prof. Stefan Krüger	
Language	DE	
Cycle	SoSe	
	The lecture starts with the definition of the early design phase and the importance of first principle approaches. The reasons for process reengineering when such kinds of methods are introduced is demonstrated. Several numerical modelling techniques are introduced and discussed for the following design relevant topics:  - Hullform representation, fairing and interpolation - Hullform design by modifying parent hulls - Modelling of subdivison - Volumetric and stability calculations - Mass distributions and longitudinal strength - Hullform Design by CFD- techniques - Propulsor and Rudder Design by CFD Techniques	
Literature	Skript zur Vorlesung.	

Course L1709: Numerical Methods in Ship Design		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Stefan Krüger	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1146	6: Ship Vibration
Courses	
<b>Title</b> Ship Vibration (L1528)	
Ship Vibration (L1529)	Recitation Section 2 3 (small)
Admission Requirements	None
Recommended Previous Knowledge	Mechanis I - III Structural Analysis of Ships I Fundamentals of Ship Structural Design
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can reproduce the acceptance criteria for vibrations on ships; they can explain the methods for the calculation of natural frequencies and forced vibrations of sructural components and the entire hull girder; they understand the effect of exciting forces of the propeller and main engine and methods for their determination
Skills	Students are capable to apply methods for the calculation of natural frequencies and exciting forces and resulting vibrations of ship structures including their assessment; they can model structures for the vibration analysis
Personal Competence	
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.
Autonomy	Students are able to detect vibration-prone components on ships, to model the structure, to select suitable calculation methods and to assess the results
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	3 hours
the Following	Energy Systems: Specialisation Marine Engineering: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Compulsory Ship and Offshore Technology: Core qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1528: Ship Vibration		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach	
Language	EN	
Cycle	WiSe	
Content	<ol> <li>Introduction; assessment of vibrations</li> <li>Basic equations</li> <li>Beams with discrete / distributed masses</li> <li>Complex beam systems</li> <li>Vibration of plates and Grillages</li> <li>Deformation method / practical hints / measurements</li> <li>Hydrodynamic masses</li> <li>Spectral method</li> <li>Hydrodynamic masses acc. to Lewis</li> <li>Damping</li> <li>Shaft systems</li> <li>Propeller excitation</li> <li>Engines</li> </ol>	
Literature	Siehe Vorlesungsskript	

Course L1529: Ship Vibration		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach	
Language	EN	
Cycle	WiSe	
Content	<ol> <li>Introduction; assessment of vibrations</li> <li>Basic equations</li> <li>Beams with discrete / distributed masses</li> <li>Complex beam systems</li> <li>Vibration of plates and Grillages</li> <li>Deformation method / practical hints / measurements</li> <li>Hydrodynamic masses</li> <li>Spectral method</li> <li>Hydrodynamic masses acc. to Lewis</li> <li>Damping</li> <li>Shaft systems</li> <li>Propeller excitation</li> <li>Engines</li> </ol>	
Literature	Siehe Vorlesungsskript	

Module M1268	3: Linear and Nonli	near Wav	<b>res</b>		
Courses					
Title			Тур	Hrs/wk	СР
Linear and Nonlinear V	Vaves (L1737)		Project-/problem- based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	Good Knowledge in Mathen	natics, Mecha	nics and Dynamics.		
Educational Objectives	After taking part successfu	lly, students h	ave reached the fol	lowing learn	ing results
Professional Competence					
Knowledge	Students are able to reflect existing terms and concepts in Wave Mechanics and to develop and research new terms and concepts.				
Skills	Students are able to apply existing methods and procesures of Wave Mechanics and to develop novel methods and procedures.				
Personal Competence					
Social Competence	Students can reach working r	esults also in g	roups.		
Autonomy	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.				
<b>Workload in Hours</b>	Independent Study Time 12	24, Study Time	e in Lecture 56		
Credit points					
Course achievement	None				
Examination	Written exam				
Examination duration and scale	2 Hours				
Assignment for the Following Curricula	Compulsory				

Course L1737: Linear and Nonlinear Waves			
Тур	Project-/problem-based Learning		
Hrs/wk	4		
СР	6		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
Lecturer	Prof. Norbert Hoffmann, Dr. Antonio Papangelo		
Language	DE/EN		
Cycle	WiSe		
Content	Introduction into the Dynamics of Linear and Nonlinear Waves.		
	G.B. Witham, Linear and Nonlinear Waves. Wiley 1999.		
Literature	C.C. Mei, Theory and Applications of Ocean Surface Waves. World Scientific 2004.		

## Module M1148: Selected topics in Naval Architecture and Ocean **Engineering** Courses Title Hrs/wk CP Typ Outfitting and Operation of Special Purpose Offshore Ships (L1896) Lecture 2 3 Design of Underwater Vessels (L0670) 2 3 Lecture Lattice-Boltzmann methods for the simulation of free surface flows Lecture 2 3 (L2066) Project-/problem-Modeling and Simulation of Maritime Systems (L2013) 2 3 based Learning Offshore Wind Parks (L0072) 2 Lecture 3 Ship Acoustics (L1605) Lecture 2 3 Ship Dynamics (L0352) 2 Lecture 3 Selected Topics of Experimental and Theoretical Fluiddynamics Lecture 2 3 (L0240) Technical Elements and Fluid Mechanics of Sailing Ships (L0873) Lecture 2 3 Technology of Naval Surface Vessels (L0765) Lecture 2 3 Module Prof. Sören Ehlers Responsible Admission None Requirements Recommended **Previous** none **Knowledge Educational** After taking part successfully, students have reached the following learning results **Objectives Professional** Competence Students are able to find their way through selected special areas within naval architecture and ocean engineering Knowledge Students are able to explain basic models and procedures in selected special areas. Students are able to interrelate scientific and technical knowledge. Students are able to apply basic methods in selected areas of ship and ocean Skills engineering. Personal Competence The students are able to communicate and cooperate in a professional environment Social Competence in the shipbuilding and component supply industry. Students can chose independently, in which fields they want to deepen their Autonomy knowledge and skills through the election of courses. Workload in Hours Depends on choice of courses Credit points 6 Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Assignment for Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective

Curricula Theoretical Mechanical Engineering: Technical Complementary Course: Elective

the Following Compulsory

Compulsory

Course L1896: Out	fitting and Operation of Special Purpose Offshore Ships
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	
Lecturer	Dr. Hendrik Vorhölter
Language	
Cycle	SoSe
Content	The lecture is separated into two parts. In the first part some basic skills necessary for the design of offshore vessels and their equipment will be repeated and where necessary deepened. In particular, the specialties which are common for the majority of offshore vessels will be addressed: rules and regulations, determination of operational limits as well as mooring and dynamic positioning.  In the second part of the lecture single types of special offshore vessels and their equipment and outfitting will be addressed. For each type the specific requirements on design and operation will be discussed. Furthermore, the students shall be engaged with the preparation of short presentation about the specific ship types as incentive for the respective unit. In particular, it is planned to discuss the following ship types in the lecture:  - Anchor handling and plattform supply vessels  - Cable -and pile lay vessels  - Jack-up vessels  - Heavy lift and offshore construction vessels  - Dredgers and rock dumping vessels  - Diving support vessels
Literature	Chakrabarti, S. (2005): Handbook of Offshore Engineering. Elsevier. Amsterdam, London  Volker Patzold (2008): Der Nassabbau. Springer. Berlin  Milwee, W. (1996): Modern Marine Salvage. Md Cornell Maritime Press. Centreville.  DNVGL-ST-N001 "Marine Operations and Marin Warranty"  IMCA M 103 "The Design and Operation of Dynamically Positioned Vessels" 2007-12  IMCA M 182 "The Safe Operation of Dynamically Positioned Offshore Supply Vessels" 2006-03  IMCA M 187 "Lifting Operations" 2007-10  IMCA SEL 185 "Transfer of Personnel to and from Offshore Vessels" 2010-03

Course L0670: Des	ign of Underwater Vessels
Тур	Lecture
Hrs/wk	
СР	
	Independent Study Time 62, Study Time in Lecture 28
Examination Form Examination	Mundliche Prurung
duration and	30 min
scale	Peter Hauschildt
Language	
Cycle	
	The lectures will give an overview about the design of underwater vessels. The Topics are:
	1.) Special requirements on the design of modern, konventional submarines
	2.) Design history
	3.) Generals description of submarines
	4.) Civil submersibles
	5.) Diving, trim, stability
	6.) Rudders and Propulsion systems
	7.) Air Independent propulsion
	8.) Signatures
Content	9.) Hydrodynamics and CFD
	10.) Weapon- and combatmangementsystems
	11.) Safety and rescue
	12.) Fatigue and shock
	13.) Ships technical systems
	14.) Electricals Systems and automation
	15.) Logisics
	16.) Accomodation
	Some of the lectures will be Hheld in form of a excursion to ThyssenKrupp Marine Systems in Kiel
Literature	Gabler, Ubootsbau

Course L2066: Lattice-Boltzmann methods for the simulation of free surface flows		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
<b>Examination Form</b>	Mündliche Prüfung	
Examination duration and scale	30 min	
Lecturer	Dr. Christian F. Janßen	
Language	DE/EN	
Cycle	WiSe	
Content	This lecture addresses Lattice Boltzmann Methods for the simulation of free surface flows. After an introduction to the basic concepts of kinetic methods (LGCAs, LBM,), recent LBM extensions for the simulation of free-surface flows are discussed. Parallel to the lecture, selected maritime free-surface flow problems are to be solved numerically.	
Literature	Krüger et al., "The Lattice Boltzmann Method - Principles and Practice", Springer Zhou, "Lattice Boltzmann Methods for Shallow Water Flows", Springer Janßen, "Kinetic approaches for the simulation of non-linear free surface flow problems in civil and environmental engineering", PhD thesis, TU Braunschweig, 2010.	

Course L2013: Modeling and Simulation of Maritime Systems			
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
<b>Examination Form</b>	Mündliche Prüfung		
Examination duration and scale			
Lecturer	Dr. Christian F. Janßen		
Language	DE/EN		
Cycle	SoSe		
Content	In the scope of this lecture, students learn to model and solve selected maritime problems with the help of numerical programs and scripts.  First, basic concepts of computational modeling are explained, from the physical modeling and discretization to the implementation and actual numerical solution of the problem. Then, available tools for the implementation and solution process are discussed, including high-level compiled and interpreted programming languages and computer algebra systems (e.g., Python; Matlab, Maple). In the second half of the class, selected maritime problems will be discussed and subsequently solved numerically by the students.		
Literature	"Introduction to Computational Modeling Using C and Open-Source Tools" (J.M. Garrido, Chapman and Hall); "Introduction to Computational Models with Python" (J.M. Garrido, Chapman and Hall); "Programming Fundamentals" (MATLAB Handbook, MathWorks);		

Course L0072: Offshore Wind Parks		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
<b>Examination Form</b>	Mündliche Prüfung	
Examination duration and scale		
Lecturer	Dr. Alexander Mitzlaff	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Nonlinear Waves: Stability, pattern formation, solitary states</li> <li>Bottom Boundary layers: wave boundary layers, scour, stability of marine slopes</li> <li>Ice-structure interaction</li> <li>Wave and tidal current energy conversion</li> </ul>	
Literature	<ul> <li>Chakrabarti, S., Handbook of Offshore Engineering, vol. I&amp;II, Elsevier 2005.</li> <li>Mc Cormick, M.E., Ocean Wave Energy Conversion, Dover 2007.</li> <li>Infeld, E., Rowlands, G., Nonlinear Waves, Solitons and Chaos, Cambridge 2000.</li> <li>Johnson, R.S., A Modern Introduction to the Mathematical Theory of Water Waves, Cambridge 1997.</li> <li>Lykousis, V. et al., Submarine Mass Movements and Their Consequences, Springer 2007.</li> <li>Nielsen, P., Coastal Bottom Boundary Layers and Sediment Transport, World Scientific 2005.</li> <li>Research Articles.</li> </ul>	

Course L1605: Ship Acoustics		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
<b>Examination Form</b>	Mündliche Prüfung	
Examination duration and scale		
Lecturer	Dr. Dietrich Wittekind	
Language	DE	
Cycle	SoSe	
Content		
Literature		

Course L0352: Ship Dynamics	
Тур	Lecture
Hrs/wk	2

Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	
Examination duration and scale	
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE
Cycle	SoSe
Content	<ul> <li>Equations of motion</li> <li>Hydrodynamic forces and moments</li> <li>Linear equations and their solutions</li> <li>Full-scale trials for evaluating the maneuvering performance</li> <li>Regulations for maneuverability</li> <li>Rudder</li> </ul> Seakeeping <ul> <li>Representation of harmonic processes</li> <li>Motions of a rigid ship in regular waves</li> <li>Flow forces on ship cross sections</li> <li>Strip method</li> <li>Consequences induced by ship motion in regular waves</li> <li>Behavior of ships in a stationary sea state</li> <li>Long-term distribution of seaway influences</li> </ul>
Literature	<ul> <li>Abdel-Maksoud, M., Schiffsdynamik, Vorlesungsskript, Institut für Fluiddynamik und Schiffstheorie, Technische Universität Hamburg-Harburg, 2014</li> <li>Abdel-Maksoud, M., Ship Dynamics, Lecture notes, Institute for Fluid Dynamic and Ship Theory, Hamburg University of Technology, 2014</li> <li>Bertram, V., Practical Ship Design Hydrodynamics, Butterworth-Heinemann, Linacre House - Jordan Hill, Oxford, United Kingdom, 2000</li> <li>Bhattacharyya, R., Dynamics of Marine Vehicles, John Wiley &amp; Sons, Canada, 1978</li> <li>Brix, J. (ed.), Manoeuvring Technical Manual, Seehafen-Verlag, Hamburg, 1993</li> <li>Claus, G., Lehmann, E., Östergaard, C). Offshore Structures, I+II, Springer-Verlag. Berlin Heidelberg, Deutschland, 1992</li> <li>Faltinsen, O. M., Sea Loads on Ships and Offshore Structures, Cambridge University Press, United Kingdom, 1990</li> <li>Handbuch der Werften, Deutschland, 1986</li> <li>Jensen, J. J., Load and Global Response of Ships, Elsevier Science, Oxford, United Kingdom, 2001</li> <li>Lewis, Edward V. (ed.), Principles of Naval Architecture - Motion in Waves and Controllability, Society of Naval Architects and Marine Engineers, Jersey City, NJ, 1989</li> <li>Lewandowski, E. M., The Dynamics of Marine Craft: Maneuvering and Seakeeping, World Scientific, USA, 2004</li> <li>Lloyd, A., Ship Behaviour in Rough Weather, Gosport, Chichester, Sussex, United Kingdom, 1998</li> </ul>

Course L0240: Selected Topics of Experimental and Theoretical Fluiddynamics				
Тур	Lecture			
Hrs/wk	2			
СР	3			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
<b>Examination Form</b>	Mündliche Prüfung			
Examination duration and scale				
Lecturer	Prof. Thomas Rung			
Language	DE			
Cycle	WiSe			
Content	Will be announced at the beginning of the lecture. Exemplary topics are  1. methods and procedures from experimental fluid mechanics 2. rational Approaches towards flow physics modelling 3. selected topics of theoretical computation fluid dynamics 4. turbulent flows			
Literature	Wird in der Veranstaltung bekannt gegeben. To be announced during the lecture.			

Course L0873: Tecl	nnical Elements and Fluid Mechanics of Sailing Ships
Тур	Lecture
Hrs/wk	
СР	
	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Thomas Rung, Peter Schenzle
Language	
Cycle	
	Principles of Sailing Mechanics:
	- Sailing: Propulsion from relative motion
	- Lifting foils: Sails, wings, rudders, fins, keels
	- Wind climate: global, seasonal, meteorological, local
	- Aerodynamics of sails and sailing rigs
	- Hydrodynamics of Hulls and fins
	Technical Elements of Sailing:
	- Traditional and modern sail types
Content	- Modern and unconventional wind propulsors
	- Hull forms and keel-rudder-configurations
	- Sailing performance Prediction (VPP)
	- Auxiliary wind propulsion (motor-sailing)
	Configuration of Sailing Ships:
	- Balancing hull and sailing rig
	- Sailing-boats and -yachts
	- Traditional Tall Sailing Ships
	- Modern Wind-Ships
Literature	<ul> <li>Vorlesungs-Manuskript mit Literatur-Liste: Verteilt zur Vorlesung</li> <li>B. Wagner: Fahrtgeschwindigkeitsberechnung für Segelschiffe, IfS-Rep. 132, 1967</li> <li>B. Wagner: Sailing Ship Research at the Hamburg University, IfS-Script 2249, 1976</li> <li>A.R. Claughton et al.: Sailing Yacht Design 1&amp;2, University of Southampton, 1998</li> <li>L. Larsson, R.E. Eliasson: Principles of Yacht Design, Adlard Coles Nautical, London, 2000</li> </ul>
	- K. Hochkirch: Entwicklung einer Messyacht, Diss. TU Berlin, 2000

Course L0765: Tec	nnology of Naval Surface Vessels
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	
Lecturer	Dr. Martin Schöttelndreyer
Language	DE
Cycle	WiSe
Content	<ul> <li>Operational scenarios, tasks, capabilities, requirements</li> <li>Product and process models, rules and regulations</li> <li>Survivability: threats, signatures, counter measures</li> <li>Design characteristics</li> <li>Energy and propulsion systems</li> <li>Command and combat systems</li> <li>Vulnerability: residual strength, residual functionality</li> </ul>
Literature	Th. Christensen, HD. Ehrenberg, H. Götte, J. Wessel: Entwurf von Fregatten und Korvetten, in: H. Keil (Hrsg.), Handbuch der Werften, Bd. XXV, Schiffahrts-Verlag "Hansa" C. Schroedter & Co., Hamburg (2000)  16th International Ship and Offshore Structures Congress: Committee V.5 - Naval Ship Design (2006)  P. G. Gates: Surface Warships - An Introduction to Design Principles, Brassey's Defence Publishers, London (1987)

Module M1232	2: Arctic Technology						
Courses							
Title Ice Engineering (L1607	<b>'</b> )	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 2			
Ice Engineering (L1615	5)	Recitation Se (small)	ection 1	2			
Ship structural design	for arctic conditions (L1575)	Project-/problem- based Learning	2	2			
Module Responsible	Prof. Sören Ehlers						
Admission Requirements	None						
Recommended Previous Knowledge							
Educational Objectives	After taking part successfully, students h	nave reached the	following lear	ning results			
Professional Competence							
Knowledge	The challenges and requirements due to ice can be explained. Ice loads can be explained and ice strengthening can be understood.						
Skills	The challenges and requirements due to ice can be assessed and the accuracy of these assessment can be evaluated. Calculation models to assess ice loads can be used and a structure can be designed accordingly.						
Personal Competence							
Social Competence	Students are capable to present their structural design and discuss their decisions constructively in a group.						
Autonomy	Independent and individual assignment tasks can be carried out and presented whereby the capabilities to both, present and defend, the skills and findings will be achieved.						
<b>Workload in Hours</b>	Independent Study Time 110, Study Time	e in Lecture 70					
Credit points	6						
Course achievement	None						
Examination							
Examination duration and scale							
Assignment for the Following Curricula	Naval Architecture and Ocean Engineering Ship and Offshore Technology: Core qual Theoretical Mechanical Engineering: Technology Theoretical Mechanical Engineering: Sp. Compulsory	lification: Elective echnical Compler	Compulsory mentary Cou	rse: Elective			

Course L1607: Ice	Engineering				
Тур	Lecture				
Hrs/wk	2				
СР	2				
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28				
Lecturer	Dr. Walter Kuehnlein				
Language	DE/EN				
Cycle	WiSe				
Content	1. Ice, Ice Properties, Ice Failure Modes and Challenges and Requirements due to Ice  1. Introduction, what is/means ice engineering 1. Description of different kinds of ice, main ice properties and different ice failure modes 1. Why is ice so different compared to open water 1. Presentation of design challenges and requirements for structures and systems in ice covered waters 2. Ice Load Determination and Ice Model Testing 1. Overview of different empirical equations for simple determination of ice loads 2. Discussion and interpretation of the different equations and results 3. Introduction to ice model tests 4. What are the requirements for ice model tests, what parameters have to be scaled 4. What can be simulated and how to use the results of such ice model tests 3. Computational Modelling of Ice-Structure Interaction Processes 4. Dynamic fracture and continuum mechanics for modelling ice-structure interaction processes 4. Alternative numerical crack propagation modelling methods. Examples of cohesive element models for real life structures. 5. Discussion of contribution of ice properties, hydrodynamics and rubble. 4. Ice Design Philosophies and Perspectives 5. What has to be considered when designing structures or systems for ice covered waters 5. What are the main differences compared to open water design Ice Management 6. Ice Management 7. What are the main ice design philosophies and why is an integrated concept so important for ice 7. Learning Objectives 7. The course will provide an introduction into ice engineering. Different kinds of ice and their different failure modes including numerical methods for ice load simulations are presented. Main design issues including design philosophies for structures and systems for ice covered waters are introduced. The course shall enable the attendees to understand the fundamental challenges due to ice covered waters and help them to understand ice engineering reports and presentations.				
Literature	<ul> <li>Proceedings OMAE</li> <li>Proceedings POAC</li> <li>Proceedings ATC</li> </ul>				

Course L1615: Ice Engineering			
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Dr. Walter Kuehnlein		
Language	DE/EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1575: Ship structural design for arctic conditions				
Тур	Project-/problem-based Learning			
Hrs/wk	2			
СР	2			
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Sören Ehlers, Dr. Rüdiger Ulrich Franz von Bock und Polach			
Language	DE/EN			
Cycle	WiSe			
Content	The structural design under ice loads will be carried out for an individual case			
Literature	FSICR, IACS PC and assorted publications			

Module M1165	5: Ship Safety					
Courses						
Title		Тур	Hrs/wk	СР		
Ship Safety (L1267)		Lecture	2	4		
Ship Safety (L1268)		Recitation (large)	Section 2	2		
Module Responsible	Prof. Stefan Krüger					
Admission Requirements	None					
Recommended Previous Knowledge	Ship Design, Hydrostatics, Statistica	l Processes				
Educational Objectives	After taking part successfully, stude	nts have reached t	he following learn	ing results		
Professional Competence						
Knowledge	The student shall lean to integrate safety aspects into the ship design process. This includes the undertsnding and application of existing rules as well as the understanding of the sfatey concept and level which is targeted by a rule. Further, methods of demonstrating equivalent safety levels are introduced.					
	he lectures starts with an overvie systems. The maritime safety organizations are introduced, the difference between prescriptive and performance based rules is tackle influence of the rules on the deign is illustrated. Further, limitations of background are shown. Concepts of demonstrating equivalent levels of following fields will be treated.	eir responses and d. Foer different e s of saftey rules wi	duties. Then, examples in ship the respect to t	the gerenal design, the he physical		
Skills	- Freeboard, water- and weathertigh	t subdivisions, ope	nings			
	- all aspects of intact stability, include	ding special probler	ns such as grain o	code		
	- damage stability for passenger ves	ssels including Stoc	kholm agreement	t		
	- damage stbility fopr cargo vessels					
	- on board stability, inclining experir	ment and stability b	oooklet			
	- Relevant manoevering information	•				
Personal Competence						
	The student learns to take responsible	-	of his designn.			
	Responsible certification of technica					
	Independent Study Time 124, Study	r Time in Lecture 56	)			
Credit points Course achievement	None					
Examination	Written exam					
Examination duration and scale						

	aval Architecture and Ocean Engineering: Core qualification: Compulsory							
Assignment for	Theoretical Mechanical Engineering: Technical Complementary Course: Elective							
the Following	Compulsory							
Curricula	Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective							
	Compulsory							

Typ Lecture  Hrs/wk 2  CP 4  Workload in Hours Independent Study Time 92, Study Time in Lecture 28  Lecturer Prof. Stefan Krüger  Language DE  Cycle WiSe  The lectures starts with an overview about general safety concepts for technical systems. The maritime safety organizations are introduced, their responses and duties. Then, the general difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  Content  Content  Content  Content  - Gamage stability for passenger vessels including Stockholm agreement  - damage stability for cargo vessels  - on board stability, inclining experiment and stability booklet	Course L1267: Ship	Safety				
CP   Workload in Hours   Independent Study Time 92, Study Time in Lecture 28	Тур	Lecture				
Workload in Hours  Lecturer Prof. Stefan Krüger  Language DE  Cycle WiSe  The lectures starts with an overview about general safety concepts for technical systems. The maritime safety organizations are introduced, their responses and duties. Then, the general difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  Content  Contant  Canage stability for passenger vessels including Stockholm agreement - damage stability for cargo vessels	Hrs/wk	2				
Language DE  Cycle WiSe  The lectures starts with an overview about general safety concepts for technical systems. The maritime safety organizations are introduced, their responses and duties. Then, the general difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  Content  - Freeboard, water- and weathertight subdivisions, openings  - all aspects of intact stability, including special problems such as grain code  - damage stability for passenger vessels including Stockholm agreement  - damage stability for cargo vessels	СР	4				
Cycle WiSe  The lectures starts with an overview about general safety concepts for technical systems. The maritime safety organizations are introduced, their responses and duties. Then, the general difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  Content  Content  - Freeboard, water- and weathertight subdivisions, openings  - all aspects of intact stability, including special problems such as grain code  - damage stability for passenger vessels including Stockholm agreement  - damage stability for cargo vessels	<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28				
The lectures starts with an overview about general safety concepts for technical systems. The maritime safety organizations are introduced, their responses and duties. Then, the general difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  Content  - Freeboard, water- and weathertight subdivisions, openings  - all aspects of intact stability, including special problems such as grain code  - damage stability for passenger vessels including Stockholm agreement  - damage stability for cargo vessels	Lecturer	Prof. Stefan Krüger				
The lectures starts with an overview about general safety concepts for technical systems. The maritime safety organizations are introduced, their responses and duties. Then, the general difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  Content  Content  Camage stability for passenger vessels including Stockholm agreement damage stability for cargo vessels	Language	DE				
systems. The maritime safety organizations are introduced, their responses and duties. Then, the gerenal difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  - Freeboard, water- and weathertight subdivisions, openings - all aspects of intact stability, including special problems such as grain code - damage stability for passenger vessels including Stockholm agreement - damage stbility fopr cargo vessels	Cycle	WiSe				
- Relevant manoevering information  Literature SOLAS, LOAD LINES, CODE ON INTACT STABILITY. Alle IMO, London.	Content	The lectures starts with an overview about general safety concepts for techn systems. The maritime safety organizations are introduced, their responses and duties. Then, the general difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, influence of the rules on the deign is illustrated . Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. following fields will be treated.  - Freeboard, water- and weathertight subdivisions, openings  - all aspects of intact stability, including special problems such as grain code  - damage stability for passenger vessels including Stockholm agreement  - damage stability for cargo vessels  - on board stability, inclining experiment and stability booklet				

Course L1268: Ship Safety				
Тур	Recitation Section (large)			
Hrs/wk	2			
СР	2			
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Stefan Krüger			
Language	DE			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

M o d u l e M11 Hydrodynamid		Mand	oeuvra	bility	and	Shallow	Wate	r Ship
Courses								
<b>Title</b> Manoeuvrability of Shi Shallow Water Ship Hy	-		98)		<b>Typ</b> Lectu Lectu		Hrs/wk 2 2	<b>CP</b> 3 3
Module Responsible	Prof. Mo	oustafa A	bdel-Maks	oud				
Admission Requirements	INODA							
Recommended Previous Knowledge	B.Sc. Sc	chiffbau						
Educational Objectives	LATEAR FA	king part	successfu	ılly, stude	nts have r	eached the foll	owing learn	ing results
Professional Competence		donts lor	n the me	tion oqua	tion and h	now to doscribe	hydrodyn	amic forces
Knowledge	The students lern the motion equation and how to describe hydrodynamic forces. They'll will be able to develop methods for analysis of manoeuvring behaviour of ships and explaining the Nomoto equation. The students will know the common model tests as well as their assets and drawbacks.  Furthermore, the students lern the basics of assessment and prognosis of ship manoeuvrabilit. Basics of characteristics of flows around ships in shallow water regarding ship propulsion and manoeuvrability will be aquired.							
<i>Skills</i> <b>Personal</b>								
Competence Social Competence Autonomy	į							
<b>Workload in Hours</b>	Indeper	ndent Stu	dy Time 1	24, Study	Time in Le	ecture 56		
Credit points								
Course achievement	None							
Examination	ļ	exam						
Examination duration and scale	180 mir	1						
Assignment for the Following Curricula	Ship an Theoret Compul	d Offshor ical Mec sory ical Mec	e Technol hanical E	ogy: Core ingineerin	qualificati g: Technic	re qualification on: Elective Co cal Complemer sation Maritim	mpulsory ntary Cour	se: Elective

Course L1597: Man	oeuvrability of Ships
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	WiSe
Content	<ul> <li>coordinates &amp; degrees of freedom</li> <li>governing equations of motion</li> <li>hydrodynamic forces &amp; moments</li> <li>ruder forces</li> <li>navigation based on linearised eq.of motion(exemplary solutions, yaw stability)</li> <li>manoeuvering test (constraint &amp; unconstraint motion)</li> <li>slender body approximation</li> </ul> Learning Outcomes Introduction into basic concepts for the assessment and prognosis ship manoeuvrabilit. Ability to develop methods for analysis of manoeuvring behaviour of ships.
Literature	<ul> <li>Crane, C. L. H., Eda, A. L., Principles of Naval Architecture, Chapter 9, Controllability, SNAME, New York, 1989</li> <li>Brix, J., Manoeuvring Technical Manual, Seehafen Verlag GmbH, Hamburg 1993</li> <li>Söding, H., Manövrieren, Vorlesungsmanuskript, Institut für Fluiddynamik und Schiffstheorie, TUHH, Hamburg, 1995</li> </ul>

Course L1598: Sha	llow Water Ship Hydrodynamics
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud, Dr. Norbert Stuntz
Language	DE/EN
Cycle	WiSe
Content	<ul> <li>Special Aspects of Shallow Water Hydrodynamics, Vertical and Horizontal Constraints, Irregularities in Channel Bed</li> <li>Fundamental Equations of Shallow Water Hydrodynamics</li> <li>Approximation of Shallow Water Waves, Boussinesq's Approximation</li> <li>Ship Waves in Deep Water and under critical, non-critical and supercritical Velocities</li> <li>Solitary Wves, Critical Speed Range, Extinction of Waves</li> <li>Aspects of Ship motions in Canals with limited water depth</li> </ul>
Literature	<ul> <li>PNA (1988): Principle of Naval Architecture, Vol. II, ISBN 0-939773-01-5</li> <li>Schneekluth (1988): Hydromechanik zum Schiffsentwurf</li> <li>Jiang, T. (2001): Ship Waves in Shallow Water, Fortschritt-Berichte VDI, Series 12, No 466, ISBN 3-18-346612-0</li> </ul>

## **Specialization Materials Science**

The focus of the specialization "materials technology" is the acquisition of in-depth knowledge and skills in materials technology. One main focus is on the creation of modern material models. Modules in the electives are the material modeling and Multi-scale modeling phenomena and methods in materials science, polymer processing, as well as plastics and composites. In addition, subjects in the Technical Supplement Course for TMBMS (according FSPO) are freely selectable.

Module M1342	2: Polymers			
Courses				
Title Typ Structure and Properties of Polymers (L0389) Processing and design with polymers (L1892) Lecture		Lecture	Hrs/wk 2 2	<b>CP</b> 3 3
Module Responsible	Dr. Hans Wittich			
Admission Requirements	None			
Recommended Previous Knowledge	Basics: chemistry / physics / material science			
Educational Objectives	After taking part successfully, stude	nts have reached the	e following learn	ing results
Professional Competence Knowledge	Students can use the knowledge of plastics and define the necessary testing and analysis.			
Skills	the interactions of chemical structure of the polymers, including to explaineighboring contexts (e.g. sustainability, environmental protection).  Students are capable of  - using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.			
Personal Competence				
Social Competence	<ul> <li>arrive at funded work results in heterogenius groups and document them.</li> <li>provide appropriate feedback and handle feedback on their own performance constructively.</li> </ul>			
Autonomy	Students are able to - assess their own strengths and wea - assess their own state of learning steps on this basis.		and to define f	<sup>-</sup> urther work

	- assess possible consequences of their professional activity.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	INONA			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Materials Science: Specialisation Engineering Materials: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory			

Course L0389: Stru	icture and Properties of Polymers
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Hans Wittich
Language	
Cycle	
Content	<ul> <li>Structure and properties of polymers</li> <li>Structure of macromolecules</li> <li>Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution</li> <li>Morphology <ul> <li>amorph, crystalline, blends</li> </ul> </li> <li>Properties</li> <li>Elasticity, plasticity, viscoelacity</li> <li>Thermal properties</li> <li>Electrical properties</li> <li>Theoretical modelling</li> <li>Applications</li> </ul>
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

Course L1892: Prod	cessing and design with polymers
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler, Dr. Hans Wittich
Language	DE/EN
Cycle	WiSe
Content	Manufacturing of Polymers: General Properties; Calendering; Extrusion; Injection Moulding; Thermoforming, Foaming; Joining Designing with Polymers: Materials Selection; Structural Design; Dimensioning
Literature	Osswald, Menges: Materials Science of Polymers for Engineers, Hanser Verlag Crawford: Plastics engineering, Pergamon Press Michaeli: Einführung in die Kunststoffverarbeitung, Hanser Verlag Konstruieren mit Kunststoffen, Gunter Erhard, Hanser Verlag

	2: Technical Elective Course for TMBMS (according to fic Regulations)
Courses	
Title	Typ Hrs/wk CP
responsible	
Admission Requirements	None
Recommended Previous Knowledge	see FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge Skills	see FSPO see FSPO
Personal Competence Social Competence Autonomy	see FSPO
-	Depends on choice of courses
Credit points	
Assignment for the Following Curricula	Compulsory  Theoretical Machanical Engineering: Specialisation Energy Systems: Elective

Module M1343	3: Fibre-polymer-composit	es			
Courses					
	es of fibre-polymer-composites (L1894) mer-composites (L1893)	<b>Typ</b> Lecture Lecture	<b>Hrs/wk</b> 2 2	<b>CP</b> 3 3	
Module Responsible	Prof. Bodo Fiedler				
Admission Requirements	None				
Recommended Previous Knowledge	Basics: chemistry / physics / materials	science			
Educational Objectives	After taking part successfully, students	s have reached th	e following learn	ing results	
Professional Competence					
Competence	Students can use the knowledge of constituents to play (fiber / matrix) and	d define the neces	ssary testing and	d analysis.	
Knowledge	They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, their processing with the different fiber types, including to explain neighboring contexts (e.g. sustainability, environmental protection).				
Skills	<ul> <li>• using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.</li> <li>• approximate sizing using the network theory of the structural elements implement and evaluate.</li> <li>• selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.</li> </ul>				
Personal Competence					
-	Students can				
Social Competence	<ul> <li>arrive at funded work results in heterogenius groups and document them.</li> <li>provide appropriate feedback and handle feedback on their own performance constructively.</li> </ul>				
Autonomy	Students are able to - assess their own strengths and weak - assess their own state of learning steps on this basis assess possible consequences of their	in specific terms		further work	
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture 56			
Credit points	6				
Course achievement	None				

Examination	Written exam
Examination duration and scale	180 min
the Following	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory Mechanical Engineering and Management: Core qualification: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1894: Stru	icture and properties of fibre-polymer-composites
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler
Language	EN
Cycle	SoSe
Content	<ul> <li>Microstructure and properties of the matrix and reinforcing materials and their interaction</li> <li>Development of composite materials</li> <li>Mechanical and physical properties</li> <li>Mechanics of Composite Materials</li> <li>Laminate theory</li> <li>Test methods</li> <li>Non destructive testing</li> <li>Failure mechanisms</li> <li>Theoretical models for the prediction of properties</li> <li>Application</li> </ul>
Literature	Hall, Clyne: Introduction to Composite materials, Cambridge University Press Daniel, Ishai: Engineering Mechanics of Composites Materials, Oxford University Press Mallick: Fibre-Reinforced Composites, Marcel Deckker, New York

Course L1893: Design with fibre-polymer-composites		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Bodo Fiedler	
Language	EN	
Cycle	SoSe	
Content	Designing with Composites: Laminate Theory; Failure Criteria; Design of Pipes and Shafts; Sandwich Structures; Notches; Joining Techniques; Compression Loading; Examples	
Literature	Konstruieren mit Kunststoffen, Gunter Erhard , Hanser Verlag	

Module M1226	6: Mechanical Properties			
Courses				
<b>Title</b> Mechanical Behaviour of Brittle Materials (L1661) Dislocation Theory of Plasticity (L1662)		<b>Typ</b> Lecture Lecture	Hrs/wk CF 2 3 2 3	•
Admission Requirements	None			
Recommended Previous Knowledge	Basics in Materials Science I/II			
Educational Objectives	After taking part successfully, stude	nts have reached the	following learning	results
Professional Competence				
Knowledge	Students can explain basic prin diagrams, tractions) and thermody entropy)	ciples of crystallogr namics (energy min	aphy, statics (fre imization, energy	ee body barriers,
Skills	Students are capable of using calculations, derivatives, integrals, t			tensor
Personal Competence				
Social Competence	Students can provide appropriate performance constructively.	feedback and hand	le feedback on th	neir own
Autonomy	Students are able to - assess their own strengths and weaknesses - assess their own state of learning in specific terms and to define further work steps on this basis guided by teachers work independently based on lectures and notes to solve problems, and to ask for help or clarifications when needed			
Workload in Hours	I Independent Study Time 124, Study	Time in Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam		_	
Examination duration and scale				
Assignment for the Following Curricula	Compulsory  Dradust Davidanment Materials	nagement: Specialises and Production:  d Production: Specialise  and Production:	: Specialisation isation Production: Specialisation M	Product Elective laterials:

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1661: Mechanical Behaviour of Brittle Materials	
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Gerold Schneider
Language	DE/EN
Cycle	SoSe
	Theoretical Strength Of a perfect crystalline material, theoretical critical shear stress
	Real strength of brittle materials Energy release reate, stress intensity factor, fracture criterion
Content	<b>Scattering of strength of brittle materials</b> Defect distribution, strength distribution, Weibull distribution
	Heterogeneous materials I Internal stresses, micro cracks, weight function,
	Heterogeneous materials II Toughening mechanisms: crack bridging, fibres
	<b>Heterogeneous materials III</b> Toughening mechanisms. Process zone
	Testing methods to determine the fracture toughness of brittle materials
	R-curve, stable/unstable crack growth, fractography
	Thermal shock
	Subcritical crack growth) v-K-curve, life time prediction
	Kriechen
	Mechanical properties of biological materials
	Examples of use for a mechanically reliable design of ceramic components
	D R H Jones, Michael F. Ashby, Engineering Materials 1, An Introduction to Properties, Applications and Design, Elesevier
	D.J. Green, An introduction to the mechanical properties of ceramics", Cambridge University Press, 1998
	B.R. Lawn, Fracture of Brittle Solids", Cambridge University Press, 1993
	D. Munz, T. Fett, Ceramics, Springer, 2001
	D.W. Richerson, Modern Ceramic Engineering, Marcel Decker, New York, 1992

Course L1662: Disl	ocation Theory of Plasticity
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Erica Lilleodden
Language	DE/EN
Cycle	SoSe
	This class will cover the principles of dislocation theory from a physical metallurgy perspective, providing a fundamental understanding of the relations between the strength and of crystalline solids and distributions of defects.
Content	We will review the concept of dislocations, defining terminology used, and providing an overview of important concepts (e.g. linear elasticity, stress-strain relations, and stress transformations) for theory development. We will develop the theory of dislocation plasticity through derived stress-strain fields, associated self-energies, and the induced forces on dislocations due to internal and externally applied stresses. Dislocation structure will be discussed, including core models, stacking faults, and dislocation arrays (including grain boundary descriptions). Mechanisms of dislocation multiplication and strengthening will be covered along with general principles of creep and strain rate sensitivity. Final topics will include non-FCC dislocations, emphasizing the differences in structure and corresponding implications on dislocation mobility and macroscopic mechanical behavior; and dislocations in finite volumes.
Literature	Vorlesungsskript Aktuelle Publikationen Bücher: Introduction to Dislocations, by D. Hull and D.J. Bacon Theory of Dislocations, by J.P. Hirth and J. Lothe Physical Metallurgy, by Peter Hassen

Module M1239	9: Experimental Micro- and	Nanomec	hanics			
Courses						
Title		Тур	Hrs/wk	СР		
Experimental Micro- ar	nd Nanomechanics (L1673)	Lecture	2	4		
Experimental Micro- ar	nd Nanomechanics (L1674)	Recitation (small)	Section 1	2		
Module Responsible	Dr. Erica Lilleodden					
Admission Requirements	None					
	Basics in Materials Science I/II, Mechar Materials Science	nical Properties	s, Phenomena and	Methods in		
Educational Objectives	After taking part successfully, students	have reached	the following learn	ing results		
Professional						
Competence						
	Students are able to describe the prin strain, modulus, strength, hardening, fa			e.g., stress,		
Knowledge	Students can explain the principles of characterization methods used for investigating microstructure (e.g., scanning electron microscopy, x-ray diffraction)					
	They can describe the fundamental relations between microstructure and mechanical properties.					
Skills	Students are capable of using standardized calculation methods to calculate and evaluate mechanical properties (modulus, strength) of different materials under varying loading states (e.g., uniaxial stress or plane strain).					
Personal Competence						
Social Competence	Students can provide appropriate fee performance constructively.	dback and ha	andle feedback or	n their own		
	Students are able to					
	- assess their own strengths and weakn	esses				
Autonomy	- assess their own state of learning ir steps on this basis guided by teachers.	n specific term	ns and to define f	urther work		
	- to be able to work independently bas and to ask for help or clarifications whe		and notes to solv	e problems,		
Workload in Hours	I Independent Study Time 138, Study Tin	ne in Lecture 4	2			
Credit points						
Course achievement						
	Written exam					
Examination duration and scale						
the Following	Materials Science: Specialisation Nano a Theoretical Mechanical Engineering: Compulsory Theoretical Mechanical Engineering:	Specialisation	Materials Science	ce: Elective		
	Compulsory					

Course L1673: Exp	erimental Micro- and Nanomechanics
Тур	Lecture
Hrs/wk	2
СР	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Erica Lilleodden
Language	DE/EN
Cycle	SoSe
Content	This class will cover the principles of mechanical testing at the micron and nanometer scales. A focus will be made on metallic materials, though issues related to ceramics and polymeric materials will also be discussed. Modern methods will be explored, along with the scientific questions investigated by such methods.  • Principles of micromechanics  • Motivations for small-scale testing  • Sample preparation methods for small-scale testing  • General experimental artifacts and quantification of measurement resolution  • Complementary structural analysis methods  • Electron back scattered diffraction  • Transmission electron microscopy  • Micro-Laue diffraction  • Nanoindentation-based testing  • Principles of contact mechanics  • Berkovich indentation  ■ Loading geometry  ■ Governing equations for analysis of stress & strain  ■ Case study:  ■ Indentation size effects  • Microcompression  ■ Loading geometry  ■ Governing equations for analysis of stress & strain  ■ Case study:  ■ Size effects in yield strength and hardening  • Microbeam-bending  ■ Loading geometry  ■ Governing equations for analysis of stress & strain  ■ Case study:  ■ Size effects in yield strength and hardening  • Microbeam-bending  ■ Loading geometry  ■ Governing equations for analysis of stress & strain  ■ Case study:  ■ Fracture strength & toughness
Literature	Vorlesungsskript Aktuelle Publikationen

Course L1674: Expe	Course L1674: Experimental Micro- and Nanomechanics			
Тур	Recitation Section (small)			
Hrs/wk	1			
СР	2			
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14			
Lecturer	Dr. Erica Lilleodden			
Language	DE/EN			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M1237	7: Methods in Theoret	tical Materials Sc	ience	
Courses				
Title Methods in Theoretical	l Materials Science (L1677) I Materials Science (L1678)	<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 1	<b>CP</b> 4 2
Module	Prof. Stefan Müller	(Smail)		
Admission				
Recommended	Knowledge of advanced mat equations and complex function Knowledge of physics, particula	ns, e.g., Mathematics I-IV	1	
Educational Objectives	After taking part successfully, s	students have reached th	e following learn	ing results
Professional Competence				
Personal Competence	evaluate the strengths and we the students are thereby able scientific problem and what accompleting the module, the select the most suitable most such as length scale, time scale	ng methods work. In of individual methodolo reaknesses of different methodolo reaknesses which methodolo reaknesses which methodorreacy can be expected for the students are able to readeling method as a function of the students are able to readeling method as a function of the students are able to readeling method as a function of the students are able to readeling method as a function of the students are able to readeling method as a function of the students are able to	ethods.  od is best suited from the simulation of various type, etc  oted to the target rials science, for	I to solve a on results. parameters group with example at
Autonomy	acquire the knowledge they r	need on their own.		
	Independent Study Time 138, S	study Time in Lecture 42		
Credit points Course achievement	None			
Examination Examination				

	duration and scale								
		Materials Sc	ience: Specia	alisation Mode	ling: Electi	ve Co	mpulsory		
ı	Assignment for							Science:	Elective
	the Following			_	•				
ı	Curricula	Theoretical	Mechanical	Engineering:	Technical	Com	plementary	Course:	Elective
		Compulsory							

Course L1677: Methods in Theoretical Materials Science				
Тур	Lecture			
Hrs/wk	2			
СР	4			
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28			
Lecturer	Prof. Stefan Müller			
Language	DE/EN			
Cycle	SoSe			
Content	<ol> <li>Introduction</li> <li>Classification of Modelling Approaches and the Solid State</li> <li>Quantum Mechanical Approaches</li> <li>Electronic states: Atoms, Molecules, Solids</li> <li>Density Functional Theory</li> <li>Spin-Dynamics</li> <li>Thermodynamic Approaches</li> <li>Thermodynamic Potentials</li> <li>Alloys</li> <li>Cluster Expansion</li> <li>Monte-Carlo-Methods</li> </ol>			
Literature	Solid State Physics, Ashcroft/Mermin, Saunders College  Computational Physics, Thijsen, Cambridge  Computational Materials Science, Ohno et al Springer  Materials Science and Engineering: An Introduction, Callister/Rethwisch, Edition 9, Wiley			

Course L1678: Methods in Theoretical Materials Science				
Тур	Recitation Section (small)			
Hrs/wk	1			
СР	2			
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14			
Lecturer	Prof. Stefan Müller			
Language	DE/EN			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M1238	3: Quantum Mechanics of So	lids					
Courses							
<b>Title</b> Quantum Mechanics of Quantum Mechanics of		Typ Lecture Recitation (small)	Hrs/wk 2 Section 1	<b>CP</b> 4 2			
Module	Prof. Stefan Müller	(Siliali)					
Admission							
Requirements  Recommended  Previous  Knowledge	equations and complex functions, e.g., M Knowledge of mechanics and physics, pa Physics	Knowledge of advanced mathematics like analysis, linear algebra, differential equations and complex functions, e.g., Mathematics I-IV Knowledge of mechanics and physics, particularly solid state physics, e.g., Materials Physics					
Educational Objectives	LATTER TAKING NART SUCCESSTUUV STUGENTS N	ave reached th	ne following learr	ing results			
Professional Competence	The master students will be able to expla	iin					
Knowledge	the basics of quantum mechanics the importance of quantum physics for the description of materials properties correlations between on quantum mechanics based phenomena between individual atoms and macroscopic properties of materials.						
Skills	The master students will then be able to connect essential materials properties in engineering with materials properties on the atomistic scale in order to understand these connections.  After attending this lecture the students can perform materials design on a quantum mechanical basis.						
Personal Competence							
Social Competence	The students are able to discuss compe with experts from fields such as physics a			sed subjects			
Autonomy	The students are able to independently problems. They can also acquire the complex questions with a quantum mech	knowledge the	ey need to dea	l with more			
<b>Workload in Hours</b>	Independent Study Time 138, Study Time	e in Lecture 42					
Credit points	6						
Course achievement	None						
Examination	Oral exam						
Examination duration and scale							
	Materials Science: Specialisation Nano ar	nd Hybrid Mate	rials: Elective Co	mpulsory			

Assignment for	Materials Sc	ience: Specia	alisation Mode	ling: Electiv	ve Cor	npulsory		
the Following	Theoretical	Mechanical	Engineering:	Specialisa	ation	Materials	Science:	Elective
Curricula	Compulsory							
	Theoretical	Mechanical	Engineering:	Technical	Comp	lementary	Course:	Elective
	Compulsory							

Course L1675: Qua	ntum Mechanics of Solids
Тур	Lecture
Hrs/wk	2
СР	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Stefan Müller
Language	DE/EN
Cycle	SoSe
	<ol> <li>Introduction</li> <li>Relevance of Quantum Mechanics</li> <li>Classification of Solids</li> <li>Foundations of Quantum Mechanics</li> <li>Reminder: Elements of Classical Mechanics</li> <li>Motivation for Quantum Mechanics</li> <li>Particle-Wave Duality</li> <li>Formalism</li> </ol>
Content	3. Elementary QM Problems 3.1 Onedimensional Problems of a Particle in a Potential 3.2 Two-Level System 3.3 Harmonic Oscillator 3.4 Electrons in a Magnetic Field 3.5 Hydrogen Atom 4. Quantum Effects in Condensed Matter
	4.1 Preliminary 4.2 Electronic Levels 4.3 Magnetism 4.4 Superconductivity 4.5 Quantum Hall Effect
	Physik für Ingenieure, Hering/Martin/Stohrer, Springer Atom- und Quantenphysik, Haken/Wolf, Springer
Literature	Grundkurs Theoretische Physik 5 1, Nolting, Springer
	Electronic Structure of Materials, Sutton, Oxford
	Materials Science and Engineering: An Introduction, Callister/Rethwisch, Edition 9, Wiley

Course L1676: Qua	Course L1676: Quantum Mechanics of Solids				
Тур	Recitation Section (small)				
Hrs/wk	1				
СР	2				
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14				
Lecturer	Prof. Stefan Müller				
Language	DE/EN				
Cycle	SoSe				
Content	See interlocking course				
Literature	See interlocking course				

Module M1152	2: Modeling Across The S	cales		
Courses				
<b>Title</b> Modeling Across The S		<b>Typ</b> Lecture Recitation	Hrs/wk 2 Section 2	<b>CP</b> 3
Modeling Across The S	cales - Excercise (L1538)	(small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear contin Mechanics II and Continuum Mechanonlinear strain, free-body principle energy).	anics (forces and	moments, stress	, linear and
Educational Objectives	After taking part successfully, studer	nts have reached tl	ne following learn	ing results
Professional Competence				
Knowledge	and can name the appropriate kind o	of modeling concep	t suited for its de	scription.
Skills	The students are able to predict fir based on the material's microstructudamage behavior of materials be particular, they are able to apply the science and evaluate and implement	ure. They are able ased on their mi eir knowledge to d	to correlate and of cromechanical buildings if the contract of	describe the behavior. In s of material
Personal Competence				
Social Competence	The students are able to develop s develop ideas further.	olutions, to preser	nt them to specia	alists and to
Autonomy	The students are able to assess the independently and on their own identified bridging modeling and acquire the kinds	entify and solve pr	oblems in the ar	
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 56	j	
Credit points				
Course achievement	None			
Examination				i
Examination duration and scale				
the Following	Materials Science: Specialisation Mod Theoretical Mechanical Engineering Compulsory Theoretical Mechanical Engineerin Compulsory	g: Technical Comp	olementary Cours	

Course L1537: Mod	Course L1537: Modeling Across The Scales		
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Christian Cyron		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>modeling of deformation mechanisms in materials at different scales (e.g., molecular dynamics, crystal plasticity, phenomenological models,)</li> <li>relationship between microstructure and macroscopic mechanical material behavior</li> <li>Eshelby problem</li> <li>effective material properties, concept of RVE</li> <li>homogenisation methods, coupling of scales (micro-meso-macro)</li> <li>micromechanical concepts for the description of damage and failure behavior</li> </ul>		
Literature	<ul> <li>D. Gross, T. Seelig, Bruchmechanik: Mit einer Einführung in die Mikromechanik, Springer</li> <li>T. Zohdi, P. Wriggers: An Introduction to Computational Micromechanics</li> <li>D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch</li> <li>G. Gottstein., Physical Foundations of Materials Science, Springer</li> </ul>		

Course L1538: Mod	leling Across The Scales - Excercise
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	SoSe
Content	<ul> <li>modeling of deformation mechanisms in materials at different scales (e.g., molecular dynamics, crystal plasticity, phenomenological models,)</li> <li>relationship between microstructure and macroscopic mechanical material behavior</li> <li>Eshelby problem</li> <li>effective material properties, concept of RVE</li> <li>homogenisation methods, coupling of scales (micro-meso-macro)</li> <li>micromechanical concepts for the description of damage and failure behavior</li> </ul>
Literature	<ul> <li>D. Gross, T. Seelig, Bruchmechanik: Mit einer Einführung in die Mikromechanik, Springer</li> <li>T. Zohdi, P. Wriggers: An Introduction to Computational Micromechanics</li> <li>D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch</li> <li>G. Gottstein., Physical Foundations of Materials Science, Springer</li> </ul>

Module M1199	9: Advanced Funct	ional Mater	rials		
Courses					
<b>Title</b> Advanced Functional N	Naterials (L1625)		<b>'yp</b> eminar	Hrs/wk 2	<b>CP</b> 6
Admission Requirements	None				
Recommended Previous Knowledge		als Science, e.g.	Materials Scie	ence I/II	
Educational Objectives	LATTAR TAKING NART CHICCACCTI	ılly, students hav	ve reached the	e following learn	ing results
Professional Competence					
Knowledge	The students will be able t their applications in to semiconductor, modern co	echnology, in p	particular met	tallic, ceramic,	polymeric,
Skills	The students will be at technical needs and, if neo principles from the microverview on modern ma materials combinations de	cessary, to design o- to the macr terials science, w	n new materia roscale. The s which enable	als considering a students will a s them to sele	architectural Iso gain an
Personal Competence					
Social Competence	The students are able to further.	) present solutio	ons to specia	lists and to de	velop ideas
	The students are able to				
Autonomy	<ul><li>assess their own str</li><li>gather new necessa</li></ul>				
Workload in Hours	Independent Study Time 1	52, Study Time i	n Lecture 28		
Credit points					
Course achievement	None				
Examination	Presentation				
Examination duration and scale	30 min				
Assignment for the Following Curricula		and Managemon pecialisation Arti Specialisation I Specialisation Ma Specialisation Ma	ent: Speciali ficial Organs implants and ledical Techno anagement ar	and Regenerative Endoprosthese cology and Contended Business Adi	ve Medicine: es: Elective rol Theory: ministration:

Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L1625: Adv	ourse L1625: Advanced Functional Materials		
Тур	Seminar		
Hrs/wk	2		
СР	6		
<b>Workload in Hours</b>	Independent Study Time 152, Study Time in Lecture 28		
Lecturer	Prof. Patrick Huber, Prof. Stefan Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Christian Cyron		
Language	DE		
Cycle	WiSe		
Content	<ol> <li>Porous Solids - Preparation, Characterization and Functionalities</li> <li>Fluidics with nanoporous membranes</li> <li>Thermoplastic elastomers</li> <li>Optimization of polymer properties by nanoparticles</li> <li>Fiber composites in automotive</li> <li>Modeling of materials based on quantum mechanics</li> <li>Biomaterials</li> </ol>		
Literature	Aktuelle Publikationen aus der Fachliteratur werden während der Veranstaltung bekanntgegeben.		

Module M1198	8: Materials Physics and At	omistic Ma	teria	ls Mod	eling
Courses					
<b>Title</b> Materials Physics (L16: Quantum Mechanics and	24) nd Atomistic Materials Modeling (L1672) Physics and Modeling (L2002)	Typ Lecture Lecture Recitation	Section	Hrs/wk 2 2	<b>CP</b> 2 2 2
Module Responsible	Prof. Patrick Huber	(small)			
Admission Requirements	None				
Recommended Previous Knowledge	Advanced mathematics, physics and natural sciences	chemistry for	studen	ts in enç	gineering or
Educational Objectives	After taking part successfully, students	have reached t	he follov	ving learn	ing results
Professional Competence	The students are able to				
Knowledge	<ul> <li>explain the fundamentals of condense</li> <li>describe the fundamentals of the thermodynamics and optics of materials</li> <li>to understand concept and realization as well as to estimate their potential an</li> </ul>	e microscopic s systems. of advanced m	structi		
Skills	After attending this lecture the students              can perform calculations regelectrical and optical properties of are able to transfer their knowled fields, e.g. materials design probelems and are able to further	arding the the force of the condensed medge to related lems.  descriptions force	atter system at technology at technology at the	stems plogical a fic mater	nd scientific
Personal Competence					
Social Competence	The students are able to present sol further.	utions to spec	ialists a	ind to de	velop ideas
Autonomy	Students are able to assess their by exemplified practice.  The students are able to assess their tasks independently.	_			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time	e in Lecture 84			
Credit points	6				
Course achievement	None				
Examination	Written exam				

Examination duration and scale	00 min				
Assignment for ⊤ the Following C Curricula ⊤	heoretical Compulsory	Mechanical			

Course L1624: Materials Physics		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Patrick Huber	
Language	DE	
Cycle	WiSe	
Content		
Literature	<ul> <li>Für den Elektromagnetismus:</li> <li>Bergmann-Schäfer: "Lehrbuch der Experimentalphysik", Band 2: "Elektromagnetismus", de Gruyter</li> <li>Für die Atomphysik:</li> <li>Haken, Wolf: "Atom- und Quantenphysik", Springer</li> <li>Für die Materialphysik und Elastizität:</li> <li>Hornbogen, Warlimont: "Metallkunde", Springer</li> </ul>	

Course L1672: Quantum Mechanics and Atomistic Materials Modeling			
Тур	Lecture		
Hrs/wk	2		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Robert Meißner		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>Why atomistic materials modeling</li> <li>Newton's equations of motion and numerical approaches</li> <li>Ergodicity</li> <li>Atomic models</li> <li>Basics of quantum mechanics</li> <li>Atomic &amp; molecular many-electron systems</li> <li>Hartree-Fock and Density-Functional Theory</li> <li>Monte-Carlo Methods</li> <li>Molecular Dynamics Simulations</li> <li>Phase Field Simulations</li> </ul>		
	Begleitliteratur zur Vorlesung (sortiert nach Relevanz):  1. Daan Frenkel & Berend Smit "Understanding Molecular Simulations" 2. Mark E. Tuckerman "Statistical Mechanics: Theory and Molecular Simulations" 3. Andrew R. Leach "Molecular Modelling: Principles and Applications"  Zur Vorbereitung auf den quantenmechanischen Teil der Klausur empfiehlt sich folgende Literatur  1. Regine Freudenstein & Wilhelm Kulisch "Wiley Schnellkurs Quantenmechanik"		

Course L2002: Exe	Course L2002: Exercises in Materials Physics and Modeling		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Robert Meißner, Prof. Patrick Huber		
Language	DE		
Cycle	WiSe		
Content			
	- Daan Frenkel & Berend Smit: Understanding Molecular Simulation from Algorithms to Applications		
Literature	- Rudolf Gross und Achim Marx: Festkörperphysik		
	- Neil Ashcroft and David Mermin: Solid State Physics		

Module M115	L: Material Modeling			
Courses				
<b>Title</b> Material Modeling (L15 Material Modeling (L15		<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3
Module Responsible	Prof. Christian Cyron	,,		
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear contine Mechanics II and Continuum Mechan nonlinear strain, free-body principle energy)	nics (forces and	moments, stress	, linear and
Educational Objectives	After taking part successfully, studen	ts have reached t	the following learn	ing results
Professional Competence				
Knowledge	The students can explain the fundam laws	entals of multidir	mensional consitut	ive material
Skills	The students can implement their or particular, the students can apply the science and evaluate the correspond	eir knowledge to	various problems	
Personal Competence				
Social Competence	The students are able to develop so develop ideas further.	olutions, to prese	nt them to specia	alists and to
Autonomy	The students are able to assess th independently and on their own identification modeling and acquire the knowledge	tify and solve pro	blems in the area	
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 5	 6	
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
Assignment for the Following Curricula	Materials Science: Specialisation Mod Mechanical Engineering and Man Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation	agement: Speci on Artificial Organ tion Implants a ion Medical Tech	alisation Materia is and Regeneration and Endoprosthese anology and Cont	ve Medicine: es: Elective rol Theory:

Product Development, Materials and Production: Core qualification: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L1535: Mate	erial Modeling
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	One of the most important questions when modeling mechanical systems in practice is how to model the behavior of the materials of their different components. In addition to simple isotropic elasticity in particular the following phenomena play key roles  - anisotropy (material behavior depending on direction, e.g., in fiber-reinforced materials)  - plasticity (permanent deformation due to one-time overload, e.g., in metal forming)  - viscoelasticity (absorption of energy, e.g., in dampers)  - creep (slow deformation under permanent load, e.g., in pipes)  This lecture briefly introduces the theoretical foundations and mathematical modeling of the above phenomena. It is complemented by exercises where simple examples problems are solved by calculations and where the implementation of the content of the lecture in computer simulations is explained. It will also briefly discussed how important material parameters can be determined from experimental data.
Literature	

Course L1536: Material Modeling		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1170	D: Phenomena and Methods	in Materials S	cience	
Courses				
	for the Characterization of Materials (L1580) ansformations (L1579)	Typ Lecture Lecture	Hrs/wk 2 2	<b>CP</b> 3 3
Module Responsible	Prof. Jörg Weißmüller			
Admission Requirements	None			
Recommended Previous Knowledge		g. Werkstoffwissensch	naft I/II	
Educational Objectives	After taking part successfully, students h	ave reached the follo	wing learn	ing results
Professional Competence				
Knowledge	The students will be able to explain the patheir applications in technology, in semiconductor, modern composite mater	particular metallic,	ceramic,	polymeric,
Skills	The students will be able to select technical needs and, if necessary, to desprinciples from the micro- to the materials of materials combinations depending on the	ign new materials con acroscale. The studen e, which enables the	nsidering a nts will a m to sele	architectural Iso gain an
Personal Competence		tions to specialists a	and to de	velop ideas
Social Competence  Autonomy	The students are able to			
Workload in Hours	I Independent Study Time 124, Study Time	e in Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
the Following	Development: Elective Compulsory Product Development, Materials and Pro Compulsory	mpulsory nd Production: Sp duction: Specialisatio d Production: Spe	pecialisation on Producti ecialisation	on Production: Elective  Materials:

Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L1580: Experimental Methods for the Characterization of Materials		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Patrick Huber	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography)</li> <li>Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements)</li> <li>Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)</li> </ul>	
Literature	William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011). William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).	

Course L1579: Pha	se equilibria and transformations
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Jörg Weißmüller
Language	DE
Cycle	WiSe
Content	Fundamentals of statistical physics, formal structure of phenomenological thermodynamics, simple atomistic models and free-energy functions of solid solutions and compounds. Corrections due to nonlocal interaction (elasticity, gradient terms). Phase equilibria and alloy phase diagrams as consequence thereof. Simple atomistic considerations for interaction energies in metallic solid solutions. Diffusion in real systems. Kinetics of phase transformations for real-life boundary conditions. Partitioning, stability and morphology at solidification fronts. Order of phase transformations; glass transition. Phase transitions in nano- and microscale systems.
Literature	D.A. Porter, K.E. Easterling, "Phase transformations in metals and alloys", New York, CRC Press, Taylor & Francis, 2009, 3. Auflage  Peter Haasen, "Physikalische Metallkunde", Springer 1994  Herbert B. Callen, "Thermodynamics and an introduction to thermostatistics", New York, NY: Wiley, 1985, 2. Auflage.  Robert W. Cahn und Peter Haasen, "Physical Metallurgy", Elsevier 1996  H. Ibach, "Physics of Surfaces and Interfaces" 2006, Berlin: Springer.

# **Specialization Product Development and Production**

At the center of the specialization "product development and production" is the acquisition of knowledge and skills for developing, designing and manufacturing of mechanical engineering products. This includes product planning, systematic and methodical development of solution concepts, the design and construction of products with special emphasis on component stress and cost considerations, to the derivation and creation of manufacturing documentation and the implementation in production.

Module M081	5: Product Planning				
Courses					
Title			Тур	Hrs/wk	СР
Product Planning (L08!	51)		Project-/problem- based Learning	3	3
Product Planning Semi	inar (L0853)		Project-/problem- based Learning	2	3
Module Responsible					
Admission Requirements	None				
Recommended Previous Knowledge	Good basic-knowledge of Bu	siness Admir	nistration		
Educational Objectives	After taking part successfully	y, students h	ave reached the fol	lowing learr	ing results
Professional Competence					
Knowledge	<ul> <li>Product Planning</li> <li>Process</li> <li>Methods</li> <li>Design thinking</li> <li>Process</li> <li>Methods</li> <li>User integration</li> </ul>				
Skills	Students will gain deep insig  Product Planning Process-related Organisational- Human-Ressou Working-tools,	l aspects related aspe rce related a	spects		
Personal Competence					
Social Competence	<ul><li>Interact within a team</li><li>Raise awareness for g</li></ul>		5		
Autonomy	Gain access to knowle     Interpret complex cas     Develop presentation	es			

<b>Workload in Hours</b>	Independent Study Time	e 110, Study Time in Le	cture 70
Credit points	6		
Course achievement		<b>Form</b> Subject theoretical	<b>Description</b> and
	165 20 70	practical work	
Examination	Written exam		
Examination			
duration and scale			
	Global Innovation Mana	gement: Core qualificati	ion: Compulsory
	International Manageme		ecialisation I. Electives Management:
Elective Compulsory  Mechanical Engineering and Management: Specialisation Manager			Specialisation Management: Elective
	Compulsory Product Development, Materials and Production: Specialisation Production		
Assignment for	Development: Elective (		roduction: Specialisation Product
the Following	Product Development, I		n: Specialisation Production: Elective
Curricula	•	Materials and Production	on: Specialisation Materials: Elective
	Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and		
	Production: Elective Cor	mpulsory	·
	Theoretical Mechanical Compulsory	Engineering: Technica	al Complementary Course: Elective

Course L0851: Pro	duct Planning
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
<b>L</b> anguage	EN
Cycle	WiSe
Content	- Guest lectures by researchers
	- Lecture on Sustainability with frequent reference to current research
	- Permanent reference to current research
	Examination:
	In addition to the written exam at the end of the module, students have to attend the PBL-exercises and prepare presentations in groups in order to pass the module. Additionally, students have the opportunity to present research papers on a voluntary base. With these presentations it is possible to gain a bonus of max. 20% for the exam. However, the bonus is only valid if the exam is passed without the bonus.
Literature	Ulrich, K./Eppinger, S.: Product Design and Development, 2nd. Edition, McGraw-Hill 2010

Course L0853: Product Planning Seminar		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Cornelius Herstatt	
Language	EN	
Cycle		
Content	Seminar is integrative part of the Module Product Planning (for content see lecture) and can not be choosen independantly.	
Literature	See lecture information "Product Planning".	

Courses				
		<b>-</b>	11. / 7	CD
<b>Title</b> The Digital Enterprise	(1.0932)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 2
Production Planning ar		Lecture	2	2
Production Planning ar		Recitation	Section <sub>1</sub>	1
Froduction Flamming at	id Control (E0930)	(small)	-	1
Exercise: The Digital E	nterprise (L0933)	Recitation (small)	Section 1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	LNIONA			
Recommended				
	Fundamentals of Production and	Quality Management	t	
Knowledge				
Educational Objectives		udents have reached	the following learn	ing results
Professional				
Competence				
Knowledge	Students can explain the contento them.	ts of the module in d	etail and take a crit	ical positio
Skills	Students are capable of choos module to industrial problems.	ing and applying m	nodels and method	ds from th
Personal Competence				
Social Competence	Students can develop joint soluti	ons in mixed teams a	and present them t	o others.
Autonomy	İ-			
Workload in Hours	Independent Study Time 96, Stu	dy Time in Lecture 84	1	
Credit points	6			
Course achievement				
	Written exam			
Examination duration and scale	180 Minuten			
	International Management and I	Engineering: Specialis	sation II. Product D	evelopme
	and Production: Elective Compul	sory		·
	Logistics, Infrastructure and M Elective Compulsory	nobility: Specialisation	on Production an	a Logistic
	Biomedical Engineering: Speciali	sation Artificial Orga	ns and Regenerativ	ve Medicine
	Elective Compulsory			
	Biomedical Engineering: Speci Compulsory	alisation Implants a	and Endoprosthes	es: Electiv
	Biomedical Engineering: Specia	lisation Medical Tec	hnology and Cont	rol Theory
Accianment for	Elective Compulsory			
Assignment for the Following	Diomicalcal Engineering. Special	lisation Management	and Business Adı	ministratio
	Compulsory Product Development, Mate	rials and Product	ion: Specialisatio	n Produ
	Development: Elective Compulso	ory	•	
	Product Development, Materi	als and Production	n: Specialisation	Productio
	Compulsory Product Development, Materials	and Production: Sn	ecialisation Materi	als: Flectiv
	Compulsory	, and Froduction. 3p	cciansación Materi	GIS. LICCUIV
	Theoretical Mechanical Engine Production: Elective Compulsory		n Product Develo	pment ar

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0932: The	Digital Enterprise
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
	Due to the developments of Industry 4.0, digitalization and interconnectivity become a strategic advantage for companies in the international competition. This lecture focuses on the relevant modules and enables the participants to evaluate current developments in this context. In particular, knowledge management, simulation, process modelling and virtual technologies are covered.
Content	<ul> <li>Business Process Management and Data Modelling, Simulation</li> <li>Knowledge and Competence Management</li> <li>Process Management (PPC, Workflow Management)</li> <li>Computer Aided Planning (CAP) and NC-Programming</li> <li>Virtual Reality (VR) and Augmented Reality (AR)</li> <li>Computer Aided Quality Management (CAQ)</li> <li>Industry 4.0</li> </ul>
Literature	Scheer, AW.: ARIS - vom Geschäftsprozeß zum Anwendungssystem. Springer-Verlag, Berlin 4. Aufl. 2002  Schuh, G. et. al.: Produktionsplanung und -steuerung, Springer-Verlag. Berlin 3. Auflage 2006  Becker, J.; Luczak, H.: Workflowmanagement in der Produktionsplanung und -steuerung. Springer-Verlag, Berlin 2004  Pfeifer, T; Schmitt, R.: Masing Handbuch Qualitätsmanagement. Hanser-Verlag, München 5. Aufl. 2007  Kühn, W.: Digitale Fabrik. Hanser-Verlag, München 2006

Course L0929: Production Planning and Control		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Hermann Lödding	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Models of Production and Inventory Management</li> <li>Production Programme Planning and Lot Sizing</li> <li>Order and Capacity Scheduling</li> <li>Selected Strategies of PPC</li> <li>Manufacturing Control</li> <li>Production Controlling</li> <li>Supply Chain Management</li> </ul>	
Literature	<ul> <li>Vorlesungsskript</li> <li>Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008</li> <li>Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002</li> </ul>	

Course L0930: Prod	Course L0930: Production Planning and Control		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	1		
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Hermann Lödding		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L0933: Exercise: The Digital Enterprise		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Axel Friedewald	
Language	DE	
Cycle		
Content	See interlocking course	
Literature	Siehe korrespondierende Vorlesung See interlocking course	

	2: Technical Elective Course for TMBMS (according to fic Regulations)
Courses	
Title	Typ Hrs/wk CP
Responsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	see FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
:	see FSPO
Personal Competence	
Social Competence	see FSPO
Autonomy	see FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Courses				
Title		Тур	Hrs/wk	СР
Integrated Product De	velopment II (L1254)	Lecture	3	3
Integrated Product De	velopment II (L1255)	Project-/problem- based Learning	2	3
Module Responsible	Prof. Dieter Krause	Prof. Dieter Krause		
Admission Requirements	LNODE			
Recommended Previous Knowledge	Basic knowledge of Integrated product development and applying CAE systems			
Educational Objectives	TATTOT TAKING NATT CHECKDECTHING CTHO	ents have reached the fo	llowing learr	ing results
Professional				
Competence	<u> </u>			
	After passing the module students	are able to:		
Knowledge	<ul> <li>explain technical terms of december of describe essential elements</li> <li>describe current problems product development.</li> </ul>	of construction manager		f integrate
	After passing the module students	are able to:		
Skills	<ul> <li>select and apply proper construction methods for non-standardized solutions of problems as well as adapt new boundary conditions,</li> <li>solve product development problems with the assistance of a workshop based approach,</li> <li>choose and execute appropriate moderation techniques.</li> </ul>			
Personal				
Competence				
	After passing the module students	are able to:		
Social Competence	<ul> <li>prepare and lead team meet</li> <li>work in teams on complex to</li> <li>represent problems and solu</li> </ul>	isks,		
	After passing the module students	are able to:		
Autonomy		nd accept a critical feed	back,	
	Independent Study Time 110, Stud	y Time in Lecture 70		
Credit points Course				
achievement	INOUG			
Examination	Oral exam			
Examination duration and scale	30 Minuten			
	Aircraft Systems Engineering: Spec Aircraft Systems Engineering: Spe Compulsory International Management and Eng and Production: Elective Compulsor	cialisation Air Transport gineering: Specialisation	ation Syster	ns: Electiv

## Assignment for the Following Curricula

Mechatronics: Specialisation System Design: Elective Compulsory

Product Development, Materials and Production: Specialisation Product

**Development: Compulsory** 

Product Development, Materials and Production: Specialisation Production: Elective

Compulsory

Product Development, Materials and Production: Specialisation Materials: Elective

Compulsory

Theoretical Mechanical Engineering: Technical Complementary Course: Elective

Compulsory

Theoretical Mechanical Engineering: Specialisation Product Development and

**Production: Elective Compulsory** 

# Course L1254: Integrated Product Development II Typ Lecture Hrs/wk 3 CP 3 Workload in Hours Independent Study Time 48, Study Time in Lecture 42 Lecturer Prof. Dieter Krause Language DE Cycle WiSe

### Lecture

The lecture extends and enhances the learned content of the module "Integrated Product Development and lightweight design" and is based on the knowledge and skills acquired there.

Topics of the course include in particular:

- Methods of product development,
- Presentation techniques,
- Industrial Design,
- Design for variety
- Modularization methods,
- Design catalogs,
- Adapted QFD matrix,
- Systematic material selection,
- Assembly oriented design,

### Construction management

### Content

- CE mark, declaration of conformity including risk assessment,
- Patents, patent rights, patent monitoring
- Project management (cost, time, quality) and escalation principles,
- Development management for mechatronics,
- Technical Supply Chain Management.

# **Exercise (PBL)**

In the exercise the content presented in the lecture "Integrated Product Development II" and methods of product development and design management will be enhanced.

Students learn an independently moderated and workshop based approach through industry related practice examples to solve complex and currently existing issues in product development. They will learn the ability to apply important methods of product development and design management autonomous and acquire further expertise in the field of integrated product development. Besides personal skills, such as teamwork, guiding discussions and representing work results will be acquired through the workshop based structure of the event under its own planning and management.

Literature	<ul> <li>Andreasen, M.M., Design for Assembly, Berlin, Springer 1985.</li> <li>Ashby, M. F.: Materials Selection in Mechanical Design, München, Spektrum 2007.</li> <li>Beckmann, H.: Supply Chain Management, Berlin, Springer 2004.</li> <li>Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater und Trainer, Weinheim, Beltz 2007.</li> <li>Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006.</li> <li>Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000.</li> <li>Simpson, T.W., Siddique, Z., Jiao, R.J.: Product Platform and Product Family Design. Methods and Applications, New York, Springer 2013.</li> </ul>
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Course L1255: Integrated Product Development II		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Dieter Krause	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1143	3: Applied Design Metho	odology in Mecha	atronics	
Courses				
	dology in Mechatronics (L1523) dology in Mechatronics (L1524)	Typ Lecture Project-/problem-	Hrs/wk 2 3	<b>CP</b> 2
Module Responsible	Prof. Thorsten Kern			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of mechanical design, electrical design or computer-sciences			
Educational Objectives	After taking part successfully, stud	dents have reached the f	following learn	ing results
Professional Competence	Science-based working on interc	disciplinary product des	ign consideri	ng targete
Knowledge Skills	application of specific product design techniques  Creative handling of processes used for scientific preparation and formulation of			
Personal Competence				
Social Competence	in small design-teams with application of common, creative methodologies.			
Autonomy	Students are enabled to optimize the design and development process according to the target and topic of the design			
	Independent Study Time 110, Stud	dy Time in Lecture 70		
Credit points Course achievement				
	Subject theoretical and practical w	vork		
Examination	30 min Presentation for a group do			
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			

Compulsory

Course L1523: App	lied Design Methodology in Mechatronics
Тур	Lecture
Hrs/wk	
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	<ul> <li>Systematic analysis and planning of the design process for products combining a multitude of disciplines</li> <li>Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation)</li> <li>Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics)</li> <li>Several design-supporting methods and tools (functional strcutures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing,)</li> <li>Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making</li> <li>Value-analysis</li> <li>Derivation of architectures and architectural management</li> <li>Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&amp;D departments, idea-identification, responsibilities and communication)</li> <li>Project-execution methods (Scrum, Kanbaan,)</li> <li>Presentation-skills</li> <li>Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces)</li> <li>Evaluation of selected methods at practical examples in small teams</li> </ul>
Literature	<ul> <li>Definition folgt</li> <li>Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007</li> <li>VDI-Richtlinien: 2206; 2221ff</li> </ul>

Course L1524: Applied Design Methodology in Mechatronics		
Тур	Project-/problem-based Learning	
Hrs/wk	3	
СР	4	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Thorsten Kern	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1281: Advanced Topics in Vibration					
Courses					
Title			Гур	Hrs/wk	СР
Advanced Topics in Vib	oration (L1743)		Project-/problem- pased Learning	4	6
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	Vibration Theory				
Educational Objectives	After taking part successfully, stu	udents ha	ve reached the fol	lowing learn	ning results
Professional Competence					
Knowledge	Students are able to reflect existing terms and concepts of Advanced Vibrations and to develop and research new terms and concepts.				
Skills	Students are able to apply existing methods and procesures of Advanced Vibrations and to develop novel methods and procedures.				
Personal Competence					
Social Competence	Students can reach working results also in groups.				
Autonomy	Students are able to approach give up novel research tasks by themselv		tasks individually	and to ident	ify and follow
Workload in Hours	Independent Study Time 124, Stu	udy Time	in Lecture 56		
Credit points					
Course achievement	None				
Examination	Written exam				
Examination duration and scale	2 Hours				
the Following	Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory				

Course L1743: Adv	Course L1743: Advanced Topics in Vibration		
Тур	Project-/problem-based Learning		
Hrs/wk	4		
СР	6		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
Lecturer	Prof. Norbert Hoffmann, Merten Tiedemann, Sebastian Kruse		
Language	DE/EN		
Cycle	SoSe		
Content	Research Topics in Vibrations.		
Literature	Aktuelle Veröffentlichungen		

	05: Technical Acoustics ycho Acoustics )	I (Acous	tic Waves,	Noise
Courses				
Title		Тур	Hrs/wk	СР
Technical Acoustics I (Acoustics ) (L0516)	Acoustic Waves, Noise Protection, Psycho	Lecture	2	3
Technical Acoustics I ( Acoustics ) (L0518)	Acoustic Waves, Noise Protection, Psycho	Recitation (large)	Section 2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Previous	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics)			
Kilowieuge	Mathematics I, II, III (in particular differ	ential equations	,	
Educational Objectives	After taking part successfully, students	have reached tl	ne following learn	ing results
Professional Competence				
Knowledge	The students possess an in-depth know noise protection, and psycho acoustic corresponding theoretical and methodi	cs and are able		
Skills	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding methodologies and measurement procedures treated within the module.			
Personal Competence				
Social Competence	Students can work in small groups on s	pecific problems	s to arrive at joint	solutions.
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible conflicting issues and limitations can be identified and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Tir	me in Lecture 56	j	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
Assignment for the Following Curricula	Compulsory	ation Cabin Syst leering: Speciali esign: Elective C d Production: Engineering Scie Technical Comp	ems: Elective Consation II. Aviation II. Aviation II. Aviation ompulsory Core qualification ence: Elective Consideration of the conside	n Systems: on: Elective mpulsory se: Elective

Course L0516: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Otto von Estorff	
Language	EN	
Cycle	SoSe	
Content	<ul> <li>Introduction and Motivation</li> <li>Acoustic quantities</li> <li>Acoustic waves</li> <li>Sound sources, sound radiation</li> <li>Sound engergy and intensity</li> <li>Sound propagation</li> <li>Signal processing</li> <li>Psycho acoustics</li> <li>Noise</li> <li>Measurements in acoustics</li> </ul>	
Literature	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg	

Course L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics )				
Тур	Recitation Section (large)			
Hrs/wk	2			
СР	3			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Otto von Estorff			
Language	EN			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M1174: Automation Technology and Systems						
Courses						
Courses		<b>T</b>	11 (1-			
<b>Title</b> Automation Technolog	y and Systems (L2329)	<b>Typ</b> Lecture	Hrs/wk 4	<b>CP</b> 4		
Automation Technology and Systems (L2331)		Project-/problem-	1	1		
Automation Technology and Systems (L2330)  Recitation Section 1				1		
Module		(small)				
Responsible Admission	Prof. Thorsten Schüppstuhl					
Requirements	None					
Recommended Previous Knowledge	without major course assessment					
Educational Objectives	After taking part successfully, studen	ts have reached the follo	owing learn	ning results		
Professional						
Competence	Students					
Knowledge	<ul> <li>know methods for a systematical analysis of automation tasks and are able to use them</li> <li>have special competences in industrial robot based automation systems</li> </ul>					
Skills	<ul> <li>analyze complex Automation tasks</li> <li>develop application based concepts and solutions</li> <li>design subsystems and integrate into one system</li> <li>investigate and evaluate safety of machinery</li> <li>create simple programs for robots and programmable logic controllers</li> <li>design of circuit for pneumatic applications</li> </ul>					
Personal						
Competence	Students are able to					
Social Competence	- find solutions for automation and ha	on environment with	qualified p	personnel at		
Autonomy	<ul> <li>Students are able to</li> <li>analyze automation tasks independently</li> <li>generate programs for robots and programmable logic devices autonomously</li> <li>develop solutions for practice oriented tasks of automation independently</li> <li>design safety concepts for automation applications</li> <li>assess consequences of their professional actions and responsibilities</li> </ul>					
	Independent Study Time 96, Study Ti	me in Lecture 84				
Credit points	6					
Course achievement	None					
Examination	Written exam					

Examination duration and scale	120 min
Assignment for the Following Curricula	

Course L2329: Automation Technology and Systems		
Тур	Lecture	
Hrs/wk	4	
СР	4	
<b>Workload in Hours</b>	Independent Study Time 64, Study Time in Lecture 56	
Lecturer	Prof. Thorsten Schüppstuhl	
Language	DE	
Cycle	SoSe	
Content		
Literature		

Course L2331: Automation Technology and Systems	
Тур	Project-/problem-based Learning
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Thorsten Schüppstuhl
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L2330: Automation Technology and Systems	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Thorsten Schüppstuhl
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1183 and analysis	3: Laser systems and	methods of mar	nufacturing	g design
Courses				
=	ocess Technologies (L1612) Production Processes (L0876)	<b>Typ</b> Lecture Lecture	Hrs/wk 2 2	<b>CP</b> 3 3
Module Responsible	Prof. Wolfgang Hintze			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stu	udents have reached the	following learn	ing results
Professional Competence Knowledge Skills				
Personal Competence Social Competence				
Autonomy Workload in Hours	Independent Study Time 124, St	udy Time in Lecture 56		
Credit points		-		
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Product Development, Mater Development: Elective Compulsor Product Development, Material Compulsory Product Development, Materials Compulsory Theoretical Mechanical Engine Production: Elective Compulsory Theoretical Mechanical Engine Compulsory	ory als and Production: and Production: Special ering: Specialisation F	Specialisation alisation Materi Product Develo	Production: als: Elective

Course L1612: Laser Systems and Process Technologies			
Тур	Lecture		
Hrs/wk			
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Claus Emmelmann		
Language	EN		
Cycle	WiSe		
Content	<ul> <li>Fundamentals of laser technology</li> <li>Laser beam sources: CO2-, Nd:YAG-, Fiber- and Diodelasers</li> <li>Laser system technology: beam forming, beam guidance systems, beam motion and beam control</li> <li>Laser-based manufacturing technologies: generation, marking, cutting, joining, surface treatment</li> <li>Quality assurance and economical aspects of laser material processing</li> <li>Markets and Applications of laser technology</li> <li>Student group exercises</li> </ul>		
Literature	<ul> <li>Hügel, H., T. Graf: Laser in der Fertigung: Strahlquellen, Systeme, Fertigungsverfahren, 3. Aufl., Vieweg + Teubner Wiesbaden 2014.</li> <li>Eichler, J., Eichler. H. J.: Laser: Bauformen, Strahlführung, Anwendungen, 7. Aufl., Springer-Verlag Berlin Heidelberg 2010.</li> <li>Steen W. M.; Mazumder J.: Laser material processing, 4th Edition, Springer-Verlag London 2010.</li> <li>J.C. Ion: Laser processing of engineering materials: principles, procedure and industrial applications, Elsevier Butterworth-Heinemann 2005.</li> <li>Gebhardt, A.: Understanding additive manufacturing, München [u.a.] Hanser 2011</li> </ul>		

Course L0876: Met	hods for Analysing Production Processes
	Lecture
Hrs/wk	
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Wolfgang Hintze
Language	DE
Cycle	WiSe
Content	<ul> <li>Modelling and simulation of maching and forming processes</li> <li>Numerical simulation of forces, temperatures, deformation in machining</li> <li>Analysis of vibration problems in maching (chatter, modal analysis,)</li> <li>Knowledge based process planning</li> <li>Design of experiments</li> <li>Machinability of nonmetallic materials</li> <li>Analysis of interaction between maching process and machine tool systems with regard to process stability and quality</li> <li>Simulation of maching processes by virtual reality methods</li> </ul>
Literature	Tönshoff, H.K.; Denkena, B.; Spanen Grundlagen, Springer (2004)  Klocke, F.; König, W.; Fertigungsverfahren Umformen, Springer (2006)  Weck, M.; Werkzeugmaschinen Fertigungssysteme 3, Springer (2001)  Weck, M.; Werkzeugmaschinen Fertigungssysteme 5, Springer (2001)

Module M0800 Methods)	6: Technical Acoustics II (Ro	oom Acous	stics, Compu	tational
Courses				
<b>Title</b> Technical Acoustics II ((L0519)	(Room Acoustics, Computational Methods)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3
	(Room Acoustics, Computational Methods)	Recitation (large)	Section 2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Acoustics I (Acoustic Waves, I Mechanics I (Statics, Mechanics of I Kinematics, Dynamics) Mathematics I, II, III (in particular differe	Materials) and	d Mechanics II (F	
Educational Objectives	After taking part successfully, students	have reached	the following learr	ing results
Professional Competence		dedge in acou	stics regarding roo	om acquetic
Knowledge	and computational mathada and are al			
Skills	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding computational methods and procedures treated within the module.			
Personal Competence				
Social Competence	Students can work in small groups on s	pecific problem	ns to arrive at joint	solutions.
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible conflicting issues and limitations can be identified and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Tin	ne in Lecture 5	66	
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	20-30 Minuten			
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory			

Course L0519: Technical Acoustics II (Room Acoustics, Computational Methods)			
Тур	Lecture		
Hrs/wk			
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Otto von Estorff		
Language	EN		
Cycle	WiSe		
Content	- Room acoustics - Sound absorber  - Standard computations - Statistical Energy Approaches - Finite Element Methods - Boundary Element Methods - Geometrical acoustics - Special formulations  - Practical applications - Hands-on Sessions: Programming of elements (Matlab)		
Literature	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin		

Course L0521: Technical Acoustics II (Room Acoustics, Computational Methods)	
Тур	Recitation Section (large)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0739	9: Factory Planning & Pr	oduction Logis	stics	
Courses				
<b>Title</b> Factory Planning (L144 Production Logistics (L		<b>Typ</b> Lecture Lecture	<b>Hrs/wk</b> 3 2	<b>CP</b> 3 3
Module Responsible	Prof. Jochen Kreutzfeldt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor degree in logistics			
Educational Objectives	After taking part successfully, stude	ents have reached th	e following learn	ing results
Professional Competence				
	The students will acquire the follow 1. The students know the latest factories.		pments in the	planning of
Knowledge	2. The students can explain basic deploy these procedures while cons			are able to
	3. The students know different me critically with these methods.	ethods of factory pla	anning and are a	able to deal
	The students will acquire the follow 1. The students are able to analyz regard to new development and the	e factories and other e need for change of	these logistical s	systems.
Skills	2. The students are able to plan an systems.	d redesign factories	and other mater	rial handling
	3. The students are able to develor revised material flow systems.	p procedures for the	implementation	of new and
Personal Competence				
	The students will acquire the follow 1. The students are able to devimprovement of existing material fl	velop plans for the		of new and
Social Competence	2. The developed planning proposa presented together.	al from the group wo	ork can be docu	mented and
	3. The students are able to derive on the planning proposals and can			
	The students will acquire the follow 1. The students can plan and replanning procedures.			ing existing
Autonomy	<ol><li>The students can evaluate inc several techniques for factory plan context.</li></ol>			
	3. The students are able to carry o of material flow systems.	ut autonomously nev	w plans and tran	sformations

<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Elective Compulsory

Course L1445: Fac	tory Planning
Тур	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Jochen Kreutzfeldt
Language	DE
Cycle	WiSe
	The lecture gives an introduction into the planning of factories and material flows. The students will learn process models and methods to plan new factories and improve existing material flow systems. The course includes three basic topics: (1) Analysis of factory and material flow systems
	(2) Development and re-planning of factory and material flow systems
Content	(3) Implementation and realization of factory planning
Content	The students are introduced into several different methods and models per topic. Practical examples and planning exercises deepen the methods and explain the application of factory planning.
	The special requirements of factory planning in an international context are discussed. Specific requirements of Current trends and issues in the factory planning round off the lecture.
	Bracht, Uwe; Wenzel, Sigrid; Geckler, Dieter (2018): Digitale Fabrik: Methoden und Praxisbeispiele. 2. Aufl.: Springer, Berlin.
	Helbing, Kurt W. (2010): Handbuch Fabrikprojektierung. Berlin, Heidelberg: Springer Berlin Heidelberg.
	Lotter, Bruno; Wiendahl, Hans-Peter (2012): Montage in der industriellen Produktion: Optimierte Abläufe, rationelle Automatisierung. 2. Aufl.: Springer, Berlin.
Literature	Müller, Egon; Engelmann, Jörg; Löffler, Thomas; Jörg, Strauch (2009): Energieeffiziente Fabriken planen und betreiben. Berlin, Heidelberg: Springer Berlin Heidelberg.
	Schenk, Michael; Müller, Egon; Wirth, Siegfried (2014): Fabrikplanung und Fabrikbetrieb. Methoden für die wandlungsfähige, vernetzte und ressourceneffiziente Fabrik. 2. Aufl. Berlin [u.a.]: Springer Vieweg.
	Wiendahl, Hans-Peter; Reichardt, Jürgen; Nyhuis, Peter (2014): Handbuch Fabrikplanung: Konzept, Gestaltung und Umsetzung wandlungsfähiger Produktionsstätten. 2. Aufl. Carl Hanser Verlag.

Course L1446: Prod	duction Logistics
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	DiplIng. Arnd Schirrmann
Language	DE
Cycle	WiSe
Content	<ul> <li>Introduction: situation, significance and main innovation focuses of logistics in a production company, aspects of procurement, production, distribution and disposal logistics, production and transport networks</li> <li>Logistics as a production strategy: logistics-oriented method of working in a factory, throughput time, corporate strategy, structured networking, reducing complexity, integrated organization, integrated product and production logistics (IPPL)</li> <li>Logistics-compatible production and process structuring; logistics-compatible product, material flow, information and organizational structures</li> <li>Logistics-oriented production control: situation and development tendencies, logistics and cybernetics, market-oriented production planning, control, monitoring, PPS systems and production control, cybernetic production organization and control, production logistics control systems.</li> <li>Production logistics planning: key performance indicators, developing a production logistics planning: key performance indicators, developing a production logistics concept, computerized aids to planning production logistics, IPPL functions, economic efficiency of logistics projects</li> <li>Production logistics controlling: production logistics and controlling, material flow-oriented cost transparency, cost controlling (process cost accounting, costs model in IPPL), process controlling (integrated production system, methods and tools, MEPOT.net method portal)</li> </ul>
Literature	Pawellek, G.: Produktionslogistik: Planung - Steuerung - Controlling. Carl Hanser Verlag 2007

Module M102!	5: Fluidics				
Courses					
<b>Title</b> Fluidics (L1256) Fluidics (L1371) Fluidics (L1257)			<b>Typ</b> Lecture Project-/problem- based Learning Recitation Section	Hrs/wk 2 1	<b>CP</b> 3 2
	1		(large)		
Module Responsible	Prof. Dieter Krause				
Admission Requirements	INODE				
Recommended	Good knowledge of kinematics and kinetic				nydrostatics
Educational Objectives		essfully, students h	ave reached the foll	owing learn	ing results
Professional Competence Knowledge	<ul> <li>After passing the module students are able to</li> <li>explain structures and functionalities of hydrostatic, pneumatic, and hydrodynamic components,</li> <li>explain the interaction of hydraulic components in hydraulic systems,</li> <li>explain open and closed loop control of hydraulic systems,</li> <li>describe functioning and applications of hydrodynamic torque converters, brakes and clutches as well as centrifugal pumps and aggregates in plant technology</li> </ul>				
Skills	<ul> <li>design and dime</li> <li>perform nume</li> <li>problem definiti</li> <li>select and adap</li> </ul>	sess hydraulic and pension hydraulic sy rical simulations of ions, ot pump characteris	oneumatic compone stems for mechanic of hydraulic syster stic curves for hydra converters and b	al applications based ulic system	ons, on abstra s
Personal Competence		ule students are ab	ele to		
Social Competence	discuss and pre	sent functional con vork autonomously.	text in groups,		
Autonomy	After passing the mod  obtain necessar	ule students are ab			
	Independent Study Tir	ne 124, Study Time	e in Lecture 56		
Credit points	6 Compulsor₿onus	Form	Descrip	ation	
		[262]	Descrip		

Course achievement	Yes No	ne A	Attestation	Simula Systen	•	statischer
Examination	Written exam					
Examination duration and scale	90					
Assignment for the Following Curricula	Compulsory International M and Production Product Development: ( Product Develo Compulsory Product Develo Compulsory Theoretical Me Compulsory	lanagemer : Elective ( elopment, Compulsor opment, M opment, M echanical	Materials and Ty aterials and Product laterials and Product Engineering: Techn	Specialisation Production: tion: Specialisa ction: Specialis	II. Product Dev Specialisation ation Production sation Materials entary Course:	Product : Elective : Elective Elective

Course L1256: Fluid	dics
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	WiSe
	Lecture
	Hydrostatics
	<ul> <li>physical fundamentals</li> <li>hydraulic fluids</li> <li>hydrostatic machines</li> <li>valves</li> <li>components</li> <li>hydrostatic transmissions</li> <li>examples from industry</li> </ul>
	<ul> <li>Pneumatics</li> <li>generation of compressed air</li> <li>pneumatic motors</li> <li>Examples of use</li> </ul>
	<ul> <li>hydrodynamics</li> <li>physical fundamentals</li> <li>hydraulic continous-flow machines</li> <li>hydrodynamic transmissions</li> <li>interoperation of motor and transmission</li> </ul>
	Exercise
Content	<ul> <li>reading and design of hydraulic diagrams</li> <li>dimensioning of hydrostatic traction and working drives</li> <li>performance calculation</li> </ul>

### Hydrodynamics

- calculation / dimensioning of hydrodynamic torque converters
- calculation / dimensioning of centrifugal pumps
- creating and reading of characteristic curves of pumps and systems

#### Field trip

• field trip to a regional company from the hydraulic industry.

#### **Exercise**

Numerical simulation of hydrostatic systems

- getting to know a numerical simulation environment for hydraulic systems
- transformation of a task into a simulation model
- simulation of common components
- variation of simulation parameters
- using simulations for system dimensioning and optimisation
- (partly) self-organised teamwork

#### Bücher

## Literature

- Murrenhoff, H.: Grundlagen der Fluidtechnik Teil 1: Hydraulik, Shaker Verlag, Aachen, 2011
- Murrenhoff, H.: Grundlagen der Fluidtechnik Teil 2: Pneumatik, Shaker Verlag, Aachen, 2006
- Matthies, H.J. Renius, K.Th.: Einführung in die Ölhydraulik, Teubner Verlag, 2006
- Beitz, W., Grote, K.-H.: Dubbel Taschenbuch für den Maschinenbau, Springer-Verlag, Berlin, aktuelle Auflage

Skript zur Vorlesung

Course L1371: Fluidics		
Тур	Project-/problem-based Learning	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Dieter Krause	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1257: Fluidics		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Dieter Krause	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

# **Specialization Robotics and Computer Science**

Module M1222	2: Design and Implementa	tion of Softwar	e Systeı	ms
Courses				
Title		Тур	Hrs/wk	СР
_	ration of Software Systems (L1657)	Lecture	2	3 3
	ation of Software Systems (L1658)	Practical Course	2	3
Module Responsible	Prof. Bernd-Christian Renner			
Admission Requirements	None			
Decemmended	- Imperativ programming languages (	C, Pascal, Fortran or sir	nilar)	
	- Simple data types (integer, double, procedure and function calls	char, boolean), arrays	, if-then-else	e, for, while,
Educational Objectives	After taking part successfully, student	s have reached the foll	owing learn	ing results
Professional				
Competence				
Knowledge	Students are able to describe mechat	ronic systems and defir	ne requirem	ents.
Skills	Students are able to design and implement mechatronic systems. They are able to argue the combination of Hard- and Software and the interfaces.			
Personal Competence				
Social Competence	Students are able to work goal-ori broadening teamwork abilities and de			earning and
Autonomy	Students are able to solve individually exercises related to this lecture with instructional direction. Students are able to plan, execute and summarize a mechatronic experiment.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
the Following	Mechatronics: Core qualification: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory			

Course L1657: Design and Implementation of Software Systems			
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Bernd-Christian Renner		
Language	EN		
Cycle	WiSe		
Content	This course covers software design and implementation of mechatronic systems, tools for automation in Java.  Content:  Introduction to software techniques Procedural Programming Object oriented software design Java Event based programming Formal methods		
Literature	<ul> <li>"The Pragmatic Programmer: From Journeyman to Master"Andrew Hunt, David Thomas, Ward Cunningham</li> <li>"Core LEGO MINDSTORMS Programming: Unleash the Power of the Java Platform" Brian Bagnall Prentice Hall PTR, 1st edition (March, 2002) ISBN 0130093645</li> <li>"Objects First with Java: A Practical Introduction using BlueJ" David J. Barnes &amp; Michael Kölling Prentice Hall/ Pearson Education; 2003, ISBN 0-13-044929-6</li> </ul>		

Course L1658: Des	Course L1658: Design and Implementation of Software Systems		
Тур	Practical Course		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Bernd-Christian Renner		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0563	3: Robotics				
Courses					
<b>Title</b> Robotics: Modelling an		Typ Lecture Recitation (small)	Section	Hrs/wk 3	<b>CP</b> 3
Module Responsible	Prof. Uwe Weltin	,			
Admission Requirements	None				
Recommended Previous Knowledge	Fundamentals of electrical engineering Broad knowledge of mechanics Fundamentals of control theory				
Educational Objectives	I ALI PE LAKINO NATI SHE PSSHINO SHINPINS N	ave reached t	the follo	wing learn	ing results
Professional					
<b>Competence</b> <i>Knowledge</i>	Students are able to describe fundar approaches for multiple problems in robo	tics.			
Skills	Students are able to derive and solve equations of motion for various manipulators.  Students can generate trajectories in various coordinate systems.  Students can design linear and partially nonlinear controllers for robotic manipulators.				
Personal Competence					
	Students are able to work goal-oriented i Students are able to recognize and impro With instructor assistance, students are and define a further course of study.	ove knowledge	e deficit	s independ	
Workload in Hours	Independent Study Time 110, Study Time	e in Lecture 7	0		
Credit points					
Course achievement	None				
Examination	Written exam				
Examination duration and scale					
the Following	Aircraft Systems Engineering: Specialisat International Management and Engineeri Compulsory International Management and Engineer and Production: Elective Compulsory Mechanical Engineering and Managemen Mechatronics: Core qualification: Compul Product Development, Materials and Development: Elective Compulsory Product Development, Materials and ProCompulsory Product Development, Materials and ProCompulsory	ng: Specialisa ing: Specialis t: Core qualifi sory nd Producti duction: Spec	ation II. I ation II. cation: ( on: Sp cialisatio	Mechatron Product D Compulsor pecialisation n Producti	ics: Elective evelopment y n Product on: Elective

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0168: Rob	Course L0168: Robotics: Modelling and Control		
Тур	Lecture		
Hrs/wk	3		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42		
Lecturer	Prof. Uwe Weltin		
Language	EN		
Cycle	WiSe		
Content	Fundamental kinematics of rigid body systems  Newton-Euler equations for manipulators  Trajectory generation  Linear and nonlinear control of robots		
Literature	Craig, John J.: Introduction to Robotics Mechanics and Control, Third Edition, Prentice Hall. ISBN 0201-54361-3  Spong, Mark W.; Hutchinson, Seth; Vidyasagar, M.: Robot Modeling and Control. WILEY. ISBN 0-471-64990-2		

Course L1305: Robotics: Modelling and Control	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1552	2: Mathematics of Neural N	etworks		
Courses				
<b>Title</b> Mathematics of Neural Mathematics of Neural		Typ Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3
Module Responsible	Dr. Jens-Peter Zemke	(ca.r)		
Admission Requirements	None			
Recommended Previous Knowledge	2. Numerical Mathematics 1/ Numer			
Educational Objectives		have reached	the following lear	ning results
Professional Competence				
Knowledge	Students are able to name, state and on their corresponding mathematical badifferent neural networks.			
Skills	Students are able to implement, unders apply neural networks.	tand, and, tail	ored to the field o	of application,
Personal Competence				
Social Competence	<ul> <li>develop and document joint solut</li> </ul>	he ideas and t	ransfer them to o	other areas of
Autonomy	<ul> <li>Students are able to</li> <li>correctly assess the time and efference assess whether the supporting the solved individually or in a team;</li> <li>define test problems for testing at assess their individual progess and help.</li> </ul>	neoretical and and expanding	practical excercise the methods;	
<b>Workload in Hours</b>	Independent Study Time 124, Study Tin	ne in Lecture 5	56	
Credit points				
Course achievement	None			
Examination				
Examination duration and scale	25 min			
the Following	Computer Science: Specialisation Intellic Computer Science: Specialisation III. Ma Computational Science and Engineerin Compulsory Technomathematics: Specialisation I. M Theoretical Mechanical Engineering: Sp Elective Compulsory	ithematics: Eleng: Specialisa athematics: E	ective Compulsory tion III. Mathema lective Compulsor	/ atics: Elective

Course L2322: Mathematics of Neural Networks		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Jens-Peter Zemke	
Language	DE/EN	
Cycle	WiSe	
Content	<ol> <li>Basics: analogy; layout of neural nets, universal approximation, NP-completeness</li> <li>Feedforward nets: backpropagation, variants of Stochastistic Gradients</li> <li>Deep Learning: problems and solution strategies</li> <li>Deep Belief Networks: energy based models, Contrastive Divergence</li> <li>CNN: idea, layout, FFT and Winograds algorithms, implementation details</li> <li>RNN: idea, dynamical systems, training, LSTM</li> <li>ResNN: idea, relation to neural ODEs</li> <li>Standard libraries: Tensorflow, Keras, PyTorch</li> <li>Recent trends</li> </ol>	
Literature	<ol> <li>Skript</li> <li>Online-Werke:         <ul> <li>http://neuralnetworksanddeeplearning.com/</li> <li>https://www.deeplearningbook.org/</li> </ul> </li> </ol>	

Course L2323: Mathematics of Neural Networks	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Courses				
Title		Тур	Hrs/wk	СР
Compilers for Embedde		Lecture Project-/problem-	3	4
Compilers for Embedde	ed Systems (L1693)	based Learning	1	2
Module Responsible	Prof. Heiko Falk			
Admission Requirements	None			
Recommended	Module "Embedded Systems"			
Previous Knowledge	C/C++ Programming skills			
Educational Objectives	After taking part successfully, stu	dents have reached the f	following learn	ing result
Professional Competence				
Knowledge	systems, the amount of software to be executed on embedded processors grows continuously due to its lower costs and higher flexibility. Because of the particular application areas of embedded systems, highly optimized and application-specific processors are deployed. Such highly specialized processors impose high demands on compilers which have to generate code of highest quality. After the successful attendance of this course, the students are able  • to illustrate the structure and organization of such compilers, • to distinguish and explain intermediate representations of various abstraction levels, and • to assess optimizations and their underlying problems in all compiler phases.  The high demands on compilers for embedded systems make effective code optimizations mandatory. The students learn in particular,  • which kinds of optimizations are applicable at the source code level, • how the translation from source code to assembly code is performed, • which kinds of optimizations are applicable at the assembly code level, • how register allocation is performed, and • how memory hierarchies can be exploited effectively.			
	Since compilers for embedded objectives (e.g., average- or wor size), the students learn to ev different criteria.	systems often have strategies.	to optimize energy dissi	oation, co
Skills	After successful completion of th level program code into machine code optimization should be ap (e.g., source or assembly code) w	code. They will be enable plied most effectively a	ed to assess v	vhich kind
	While attending the labs, the st compiler including optimizations.	udents will learn to imp	olement a full	y function
Personal Competence				
-	Students are able to solve simila results accordingly.	r problems alone or in a	group and to	present t

Autonomy	associate this knowledge with other classes.
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L1692: Compilers for Embedded Systems		
	Lecture	
Hrs/wk		
СР		
	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Heiko Falk	
Language	DE/EN	
Cycle	SoSe	
Content	<ul> <li>Introduction and Motivation</li> <li>Compilers for Embedded Systems - Requirements and Dependencies</li> <li>Internal Structure of Compilers</li> <li>Pre-Pass Optimizations</li> <li>HIR Optimizations and Transformations</li> <li>Code Generation</li> <li>LIR Optimizations and Transformations</li> <li>Register Allocation</li> <li>WCET-Aware Compilation</li> <li>Outlook</li> </ul>	
Literature	<ul> <li>Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2<sup>nd</sup> Edition, Springer, 2012.</li> <li>Steven S. Muchnick. Advanced Compiler Design and Implementation. Morgan Kaufmann, 1997.</li> <li>Andrew W. Appel. Modern compiler implementation in C. Oxford University Press, 1998.</li> </ul>	

Course L1693: Compilers for Embedded Systems	
Тур	Project-/problem-based Learning
Hrs/wk	1
СР	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heiko Falk
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0627	7: Machine Learning and	Data Mining		
Courses				
<b>Title</b> Machine Learning and Machine Learning and	-	<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 4 2
Module Responsible	NN	(0.112.11)		
Admission Requirements	None			
Recommended Previous Knowledge	• Calculus			
Educational Objectives	After taking part successfully, stude	ents have reached t	the following learn	ning results
Professional Competence				
Knowledge	Students can explain the different learning approaches, and they can each of the two basic approaches, of incrementally incoming data. For suitable representation formalism parameters, or structures used in with different algorithms. Student techniques. They depict how the performance of the perfo	enumerate basic meither on the basis r dealing with uncers, and they expended these formalisms are also able terformance of learn summarize how	nachine learning to of static data, or ertainty, students obtain how axiom can be learned a o sketch differented classifiers can this influences con	echnique for on the basis can describe s, features, utomatically at clustering be improved amputational
Skills	Student derive decision trees and, static data tables and are able to rather present and apply the basic apply the BME, MAP, ML, and EM networks and compare the difference Gaussian mixture learning. They can support vector machines, and nan properties. Students can describe to components of those techniques techniques, e.g., k-means clustering distinguish various ensemble learn of those techniques.	name and explain he idea of first-order algorithms for learn algorithms. They an contrast kNN claims their basic apploasic clustering tect. Students compand and nearest neighbors.	pasic optimization r inductive leaning parameters also know how assifiers, neural neication areas and hniques and explaine related machighbor classification	techniques.  ng. Students  of Bayesian  to carry out  etworks, and  algorithmic  ain the basic  ine learning  on. They car
Personal Competence				
Social Competence				
Autonomy Workload in Hours	I Independent Study Time 124, Study	V Time in Lecture 5	 6	
Credit points		,c III Lecture 3	<u> </u>	
Course achievement	None			
Examination	Written exam			
Examination				

duration and scale	
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0340: Mac	hine Learning and Data Mining
Тур	Lecture
Hrs/wk	2
СР	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	SoSe
Content	<ul> <li>Decision trees</li> <li>First-order inductive learning</li> <li>Incremental learning: Version spaces</li> <li>Uncertainty</li> <li>Bayesian networks</li> <li>Learning parameters of Bayesian networks BME, MAP, ML, EM algorithm</li> <li>Learning structures of Bayesian networks</li> <li>Gaussian Mixture Models</li> <li>kNN classifier, neural network classifier, support vector machine (SVM) classifier</li> <li>Clustering Distance measures, k-means clustering, nearest neighbor clustering</li> <li>Kernel Density Estimation</li> <li>Ensemble Learning</li> <li>Reinforcement Learning</li> <li>Computational Learning Theory</li> </ul>
Literature	<ol> <li>Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russel, Peter Norvig, Prentice Hall, 2010, Chapters 13, 14, 18-21</li> <li>Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press 2012</li> </ol>

Course L0510: Machine Learning and Data Mining	
Тур	Recitation Section (small)
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M055	1: Pattern Recognition and Data Compre	ssion	
Courses			
<b>Title</b> Pattern Recognition ar	Typ and Data Compression (L0128) Lecture	Hrs/wk 4	<b>CP</b> 6
Admission Requirements	None None		
	Linear algebra (including PCA, unitary transforms), stochas arithmetics	tics and stati	stics, binary
Educational Objectives	After taking part successfully, students have reached the fo	ollowing learn	ing results
Professional Competence			
Knowledge	Students can name the basic concepts of pattern recognition. Students are able to discuss logical connections between the course and to explain them by means of examples.		•
Skills	Students can apply statistical methods to classification recognition and to prediction in data compression. On methodical basis they can analyze characteristic variations and describe data compression and video able to use highly sophisticated methods and process Students are capable of assessing different solution approad decision-making areas.	a sound the value assign signal codin es of the si	oretical and ments and g. They ard ubject area
Personal Competence			
Social Competence	e k.A.		
Autonomy	Students are capable of identifying problems independer scientifically, using the methods they have learnt.	ntly and of s	olving then
Workload in Hours	s Independent Study Time 124, Study Time in Lecture 56		
Credit points	s 6		
Course achievement	INONE		
Examination	<b>n</b> Written exam		
Examination duration and scale	d 60 Minutes, Content of Lecture and materials in StudIP		
	Computer Science: Specialisation II: Intelligence Engineering Electrical Engineering: Specialisation Information and Compulsory Information and Communication Systems: Specialisation Systems, Focus Software and Signal Processing: Elective Compulsory Focus Signal Processing: Elective Compulsory	communication  ecure and Decompulsory	n Systems

Assignment for	International Management and Engineering: Specialisation II. Information
the Following	Technology: Elective Compulsory
Curricula	International Management and Engineering: Specialisation II. Electrical Engineering:
	Elective Compulsory
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
	Mechatronics: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory

Course L0128: Patt	ern Recognition and Data Compression
Тур	Lecture
Hrs/wk	4
СР	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Rolf-Rainer Grigat
Language	EN
Cycle	SoSe
Content	Structure of a pattern recognition system, statistical decision theory, classification based on statistical models, polynomial regression, dimension reduction, multilayer perceptron regression, radial basis functions, support vector machines, unsupervised learning and clustering, algorithm-independent machine learning, mixture models and EM, adaptive basis function models and boosting, Markov random fields  Information, entropy, redundancy, mutual information, Markov processes, basic coding schemes (code length, run length coding, prefix-free codes), entropy coding (Huffman, arithmetic coding), dictionary coding (LZ77/Deflate/LZMA2, LZ78/LZW), prediction, DPCM, CALIC, quantization (scalar and vector quantization), transform coding, prediction, decorrelation (DPCM, DCT, hybrid DCT, JPEG, JPEG-LS), motion estimation, subband coding, wavelets, HEVC (H.265,MPEG-H)
Literature	Schürmann: Pattern Classification, Wiley 1996 Murphy, Machine Learning, MIT Press, 2012 Barber, Bayesian Reasoning and Machine Learning, Cambridge, 2012 Duda, Hart, Stork: Pattern Classification, Wiley, 2001 Bishop: Pattern Recognition and Machine Learning, Springer 2006 Salomon, Data Compression, the Complete Reference, Springer, 2000 Sayood, Introduction to Data Compression, Morgan Kaufmann, 2006 Ohm, Multimedia Communication Technology, Springer, 2004 Solari, Digital video and audio compression, McGraw-Hill, 1997 Tekalp, Digital Video Processing, Prentice Hall, 1995

Module M0692	2: Approximation and St	ability		
Courses				
<b>Title</b> Approximation and Sta Approximation and Sta		<b>Typ</b> Lecture Recitation	Hrs/wk C 3 4 Section 1 2	
	-	(small)		
повренение	Prof. Marko Lindner			
Admission Requirements	None			
Recommended Previous Knowledge	eigenvalues, singular values	·	·	problems
Educational Objectives	After taking part successfully, stud	ents have reached	the following learning	g results
Professional Competence				
Knowledge	<ul> <li>sketch and interrelate basic operators),</li> <li>name and understand concr</li> <li>name and explain basic stab</li> <li>discuss spectral quantities, or</li> </ul>	ete approximation ility theorems,	methods,	
Skills	<ul> <li>Students are able to</li> <li>apply basic results from fund</li> <li>apply approximation method</li> <li>apply stability theorems,</li> <li>compute spectral quantities,</li> <li>apply regularisation method</li> </ul>	ds,		
Personal				
Competence Social Competence	Students are able to solve specific appropriately (e.g. as a seminar pr		ps and to present the	eir result
Autonomy	<ul> <li>Students are capable of chertheir own. They can specify help in solving them.</li> <li>Students have developed superiods in a goal-oriented m</li> </ul>	open questions pro	ecisely and know who e to be able to work	ere to ge
Workload in Hours	Independent Study Time 124, Stud	y Time in Lecture 5	56	
Credit points	6			
Course achievement	CompulsorBonusFormYesNonePresentation		Description	
Examination	Oral exam			
Examination duration and scale				
	Electrical Engineering: Specialisa	tion Control and	Power Systems Eng	gineering

<b>A</b> a si a a a a a a a a a a a a a a a a a	Elective Compulsory  Mathematical Modelling in Engineering: Theory, Numerics, Applications:  Specialisation I. Numerics (TUHH): Elective Compulsory
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory

Course L0487: App	roximation and Stability
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	SoSe
Content	This course is about solving the following basic problems of Linear Algebra,  • systems of linear equations, • least squares problems, • eigenvalue problems  but now in function spaces (i.e. vector spaces of infinite dimension) by a stable approximation of the problem in a space of finite dimension.  Contents:
	<ul> <li>convolution and Toeplitz operators</li> <li>crash course on C*-algebras</li> <li>convergence of condition numbers</li> <li>convergence of spectral quantities: spectrum, eigen values, singular values, pseudospectra</li> <li>regularisation methods (truncated SVD, Tichonov)</li> </ul>
Literature	<ul> <li>R. Hagen, S. Roch, B. Silbermann: C*-Algebras in Numerical Analysis</li> <li>H. W. Alt: Lineare Funktionalanalysis</li> <li>M. Lindner: Infinite matrices and their finite sections</li> </ul>

Course L0488: Approximation and Stability		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Marko Lindner	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M083!	5։ Hւ	ımano	id Rob	otics					
Courses									
<b>Title</b> Humanoid Robotics (LC	0663)					<b>Typ</b> Seminar		Hrs/wk 2	<b>CP</b> 2
		k Göttsch	ı						
Admission Requirements	None								
Recommended Previous Knowledge	•		tion to con theory and						
Educational Objectives	LΔΠΩΓ	taking pa	rt success	sfully, stu	udents ha	ave reached t	the follow	wing learn	ing results
Professional Competence									
Knowledge						oots. ol concepts f	or differ	ent tasks	in humanoid
Skills	•	based or Students	n specified s generaliz	d literatu ze devel	ure loped res	ut selected a ults and pres ive a present	ent then		
Personal Competence									
Social Competence		present They ar	them	o provid	le appro	ng solutions i			
Autonomy		presenta Students	ation for sp s familiariz ow presen	pecific to ze them	asks and selves wi	and drawba select the be ith a scientific students, su	est soluti c field, a	on ire able of	introduce i
Workload in Hours	!	endent St	tudy Time	32, Stu	dy Time i	n Lecture 28			
Credit points									
Course achievement	!								
Examination Examination duration and scale	30 mi								
	Mecha Mecha Biome Electi Biome	atronics: S edical Eng ve Compu	Specialisa gineering: ulsory	tion Sys Speciali	tem Desi isation Ai	ystems and R gn: Elective ( tificial Organ Implants a	Compuls is and Re	ory egenerativ	ve Medicine

Assignment for	Biomedical Engineering: Specialisation Medical Technology and Control Theory:
the Following	Elective Compulsory
Curricula	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory

Course L0663: Humanoid Robotics				
Тур	Seminar			
Hrs/wk	2			
СР	2			
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Patrick Göttsch			
Language	DE			
Cycle	SoSe			
Content	<ul> <li>Grundlagen der Regelungstechnik</li> <li>Control systems theory and design</li> </ul>			
Literature	- B. Siciliano, O. Khatib. "Handbook of Robotics. Part A: Robotics Foundations", Springer (2008).			

Module M0939	9: Control Lab A			
Courses				
Title Control Lab I (L1093) Control Lab II (L1291) Control Lab III (L1665) Control Lab IV (L1666)		<b>Typ</b> Practical Course Practical Course Practical Course Practical Course	Hrs/wk 1 1 1	CP 1 1 1 1
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul> <li>State space methods</li> <li>LQG control</li> <li>H2 and H-infinity optim</li> <li>uncertain plant models</li> <li>LPV control</li> </ul>			
Educational Objectives	After taking part successfully,	students have reached the foll	owing learn	ing results
Professional Competence				
Knowledge		the difference between validation	tion of a co	ontrol lop in
Skills	System Identification To for controller synthesis  They are capable of us for the design and imple  They are capable of us Toolbox) for the mixed-optimal controllers  They are capable of reimplementing a robust  They are capable of us	of applying basic system ider colbox) to identify a dynamic raining standard software tools (Pementation of LQG controllers sing standard software tools sensitivity design and the implementation of	model that on Matlab Cont (Matlab Robert Rob	rol Toolbox)  oust Control of H-infinity  esigning and
Personal Competence				
Social Competence	<ul> <li>Students can work in results</li> </ul>	teams to conduct experime	nts and do	cument the
Autonomy	<ul> <li>Students can indepen validate control loops</li> </ul>	dently carry out simulation	studies to	design and
<b>Workload in Hours</b>	Independent Study Time 64, S	tudy Time in Lecture 56		
Credit points	4			
Course achievement	None			
Examination	Written elaboration			
Examination				

duration and scale	
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L1093: Control Lab I		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Herbert Werner, Patrick Göttsch, Adwait Datar	
Language	EN	
Cycle	WiSe/SoSe	
Content	One of the offered experiments in control theory.	
	Experiment Guides	
Literature		

Course L1291: Control Lab II		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Herbert Werner, Patrick Göttsch, Adwait Datar	
Language	EN	
Cycle	WiSe/SoSe	
	One of the offered experiments in control theory.	
Literature	Experiment Guides	

Course L1665: Control Lab III		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Herbert Werner, Patrick Göttsch, Adwait Datar	
Language	EN	
Cycle	WiSe/SoSe	
	One of the offered experiments in control theory.	
Literature	Experiment Guides	

Course L1666: Control Lab IV		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Herbert Werner, Patrick Göttsch, Adwait Datar	
Language	EN	
Cycle	WiSe/SoSe	
	One of the offered experiments in control theory.	
Literature	Experiment Guides	

Module M0633	3: Industrial Process Autom	ation		
Courses				
Title Industrial Process Auto		<b>Typ</b> Lecture Recitation	Hrs/wk 2 Section 2	<b>CP</b> 3
- Tradscriat Fracess Acto		(small)	_	
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Previous	mathematics and optimization methods principles of automata principles of algorithms and data structu programming skills	ires		
Educational Objectives	After taking part successfully, students h	nave reached	the following learr	ning results
Professional Competence				
Knowledge	The students can evaluate and assess properties of processes and explain met compare methods for process modelli actual problems. They can discuss sch problems and give a detailed explana different programming methods. The smethods from robotics and sensor s'cyberphysical systems' and 'industry 4.6	thods for proceing and select neduling methation of adva- students can ystems as w	ess analysis. The set an appropriate mods in the contentages and disade relate process au	students can method for ext of actual vantages of itomation to
Skills	The students are able to develop a accordingly. This involves taking into a algorithmic complexity, and implementa	account optim	nal scheduling, un	
Personal				
Competence  Social Competence	The students work in teams to solve pro	blems.		
Autonomy	The students can reflect their knowledge	e and docume	nt the results of th	neir work.
<b>Workload in Hours</b>	Independent Study Time 124, Study Tim	e in Lecture 5	66	
Credit points	6			
Course achievement	Compulsor <b>₽</b> onusFormNo10 %Excercises	D	escription	
Examination	Written exam			
Examination duration and scale				
	Bioprocess Engineering: Specialisation A Compulsory Chemical and Bioprocess Engineering: S Elective Compulsory Chemical and Bioprocess Engineering: S	pecialisation (	Chemical Process	Engineering:

the Following	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory
	Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0344: Industrial Process Automation		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>foundations of problem solving and system modeling, discrete event systems</li> <li>properties of processes, modeling using automata and Petri-nets</li> <li>design considerations for processes (mutex, deadlock avoidance, liveness)</li> <li>optimal scheduling for processes</li> <li>optimal decisions when planning manufacturing systems, decisions under uncertainty</li> <li>software design and software architectures for automation, PLCs</li> </ul>	
	J. Lunze: "Automatisierungstechnik", Oldenbourg Verlag, 2012 Reisig: Petrinetze: Modellierungstechnik, Analysemethoden, Fallstudien; Vieweg+Teubner 2010 Hrúz, Zhou: Modeling and Control of Discrete-event Dynamic Systems; Springer 2007 Li, Zhou: Deadlock Resolution in Automated Manufacturing Systems, Springer 2009 Pinedo: Planning and Scheduling in Manufacturing and Services, Springer 2009	

Course L0345: Industrial Process Automation		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0552	2: 3D Computer Vision			
Courses				
Title 3D Computer Vision (L		<b>Typ</b> Lecture Recitation	Hrs/wk 2 Section 2	<b>CP</b> 3
3D Computer Vision (L	0130)	(small)	2	3
Module Responsible	Prof. Rolf-Rainer Grigat			
Admission Requirements	None			
Recommended Previous Knowledge	<ul> <li>Knowlege of the modules Digit Data Compression are used in</li> <li>Linear Algebra (including PC Marquardt), basics of stochas cannot be explained in detail d</li> </ul>	the practical task A, SVD), nonline stics and basics	c ear optimization of Matlab are r	(Levenberg-
Educational Objectives	After taking part successfully, studen	ts have reached t	the following learr	ning results
Professional Competence				
Knowledge	Students can explain and describe the	e field of projecti	ve geometry.	
Skills	<ul> <li>Students are capable of</li> <li>Implementing an exemplary 3D or volumetric analysis task</li> <li>Using highly sophisticated methods and procedures of the subject area</li> <li>Identifying problems and</li> <li>Developing and implementing creative solution suggestions.</li> <li>With assistance from the teacher students are able to link the contents of the three subject areas (modules)</li> <li>Digital Image Analysis</li> <li>Pattern Recognition and Data Compression and</li> <li>3D Computer Vision</li> <li>in practical assignments.</li> </ul>			
Personal Competence				
Social Competence	Students can collaborate in a small te system to reconstruct a three-dimens			
	Students are able to solve simple contents of the lectures and the exer		lently with refer	ence to the
Autonomy	Students are able to solve detailed tutorial's programming task.	problems indep	endently with th	e aid of the
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 5	6	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 Minutes, Content of Lecture and m	naterials in StudIF	)	

	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Software and Signal Processing: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective
	· ·
Assignment for	
the Following	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
Curricula	Microelectronics and Microsystems: Specialisation Communication and Signal
	Processing: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science:
	Elective Compulsory

Course L0129: 3D Computer Vision			
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Rolf-Rainer Grigat		
Language	EN		
Cycle	WiSe		
Content	<ul> <li>Projective Geometry and Transformations in 2D und 3D in homogeneous coordinates</li> <li>Projection matrix, calibration</li> <li>Epipolar Geometry, fundamental and essential matrices, weak calibration, 5 point algorithm</li> <li>Homographies 2D and 3D</li> <li>Trifocal Tensor</li> <li>Correspondence search</li> </ul>		
Literature	<ul> <li>Skriptum Grigat/Wenzel</li> <li>Hartley, Zisserman: Multiple View Geometry in Computer Vision. Cambridge 2003.</li> </ul>		

Course L0130: 3D Computer Vision		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Rolf-Rainer Grigat	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1336	6: Soft Computing - Introduction to Machine Learning		
Courses			
<b>Title</b> Soft Computing - Introd	Typ Hrs/wk CP duction to Machine Learning (L1869) Lecture 4 6		
Module Responsible	Prof. Karl-Heinz Zimmermann		
Admission Requirements	INONA		
	Bachelor in Computer Science.  Basics in higher mathematics are inevitable, like calculus, linear algebra, graph theory, and optimization.		
Educational Objectives	I ALIER TAKING NAG SUCCESSIONV SUIGENIS NAVE FEACHED THE IONOWING JEAGNING FESIUS		
Professional Competence			
Knowledge	Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models, phylogenetic tree models, classical regression and clustering methods, neural networks, and fuzzy controllers.		
Skills	Students can apply the relevant algorithms and determine their complexity, and they can make use of the statistics language R.		
Personal Competence			
_	Students are able to solve specific problems alone or in a group and to present the results accordingly.		
Autonomy	Students are able to acquire new knowledge from newer literature and to associate the acquired knowledge to other fields.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points			
Course achievement	None		
Examination	Oral exam		
Examination duration and scale	25 min		
Assignment for the Following Curricula	Theoretical Machanical Complementary Course: Elective Compulsory		

Course L1869: Soft	Computing - Introduction to Machine Learning
Тур	Lecture
Hrs/wk	4
СР	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Karl-Heinz Zimmermann, Dr. Mehwish Saleemi
Language	DE/EN
Cycle	WiSe
Content	Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models, phylogenetic tree models, neural networks, and fuzzy controllers. In particular, inference and learning in belief networks are important topics that the students should be able to master. Students can apply the relevant algorithms and determine their complexity, and they can make use of the statistics language R.
Literature	<ol> <li>David Barber, Bayes Reasoning and Machine Learning, Cambridge Univ. Press, Cambridge, 2012.</li> <li>Volker Claus, Stochastische Automaten, Teubner, Stuttgart, 1971.</li> <li>Ernst Klement, Radko Mesiar, Endre Pap, Triangular Norms, Kluwer, Dordrecht, 2000.</li> <li>Timo Koski, John M. Noble, Bayesian Networks, Wiley, New York, 2009.</li> <li>Dimitris Margaritis, Learning Bayesian Network Model Structure from Data, PhD thesis, Carnegie Mellon         University, Pittsburgh, 2003.</li> <li>Hidetoshi Nishimori, Statistical Physics of Spin Glasses and Information Processing, Oxford Univ. Press,         London, 2001.</li> <li>James R. Norris, Markov Chains, Cambridge Univ. Press, Cambridge, 1996.</li> <li>Maria Rizzo, Statistical Computing with R, Chapman &amp; Hall/CRC, Boca Raton, 2008.</li> <li>Peter Sprites, Clark Glymour, Richard Scheines, Causation, Prediction, and Search, Springer, New York,         1993.     </li> <li>Raul Royas, Neural Networks, Springer, Berlin, 1996.</li> <li>Lior Pachter, Bernd Sturmfels, Algebraic Statistics for Computational Biology, Cambridge Univ. Press,         Cambridge, 2005.     </li> <li>David A. Sprecher, From Algebra to Computational Algorithms, Docent Press,         Boston, 2017.     </li> <li>Karl-Heinz Zimmermann, Algebraic Statistics, TubDok, Hamburg, 2016.</li> </ol>

Module M0550	): Digital Image Ana	lysis		
Courses				
<b>Title</b> Digital Image Analysis	(10126)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 6
Module		Lecture	4	0
Responsible	Prof. Rolf-Rainer Grigat			
Admission Requirements	None			
Recommended Previous Knowledge	theory, interpolation and systems), linear algebra (Ei statistics (expectation values	nsional signals (convolution and decimation, Fourier transform, genvalue decomposition, SVD), s, influence of sample size, corre arameters), basics of Matlab, bas	linear tir basic stoc elation and	me-invariant thastics and covariance,
Educational Objectives	After taking part successfully	, students have reached the follo	owing learn	ing results
Professional Competence				
Knowledge	in their context • Interpret effects of t	sensorics	imaging s	_
Skills	<ul> <li>Identify problems and</li> <li>Students can solve simple a design of image processing a</li> <li>Students are able to assess decision-making areas.</li> </ul>	ed methods and procedures of the develop and implement creative arithmetical problems relating to and image analysis systems.  So different solution approached by the state of the processes in the state of the sta	e solutions. O the speci es in multi	fication and
Personal Competence Social Competence	k.A.			
Autonomy	Students can solve image an	alysis tasks independently using	the releva	nt literature.
Workload in Hours	Independent Study Time 124	, Study Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			

Examination duration and scale	60 Minutes, Content of Lecture and materials in StudIP
the Following	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Software and Signal Processing: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

Course L0126: Digital Image Analysis		
Тур	Lecture	
Hrs/wk	4	
СР	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Rolf-Rainer Grigat	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>Image representation, definition of images and volume data sets, illumination, radiometry, multispectral imaging, reflectivities, shape from shading</li> <li>Perception of luminance and color, color spaces and transforms, color matching functions, human visual system, color appearance models</li> <li>imaging sensors (CMOS, CCD, HDR, X-ray, IR), sensor characterization(EMVA1288), lenses and optics</li> <li>spatio-temporal sampling (interpolation, decimation, aliasing, leakage, moiré, flicker, apertures)</li> <li>features (filters, edge detection, morphology, invariance, statistical features, texture)</li> <li>optical flow (variational methods, quadratic optimization, Euler-Lagrange equations)</li> <li>segmentation (distance, region growing, cluster analysis, active contours, level sets, energy minimization and graph cuts)</li> <li>registration (distance and similarity, variational calculus, iterative closest points)</li> </ul>	
Literature	Bredies/Lorenz, Mathematische Bildverarbeitung, Vieweg, 2011 Wedel/Cremers, Stereo Scene Flow for 3D Motion Analysis, Springer 2011 Handels, Medizinische Bildverarbeitung, Vieweg, 2000 Pratt, Digital Image Processing, Wiley, 2001 Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1989	

Module M1302	2: Applied Humanoid Robot	ics		
Courses				
<b>Title</b> Applied Humanoid Rob	potics (L1794)	<b>Typ</b> Project-/problem- based Learning	Hrs/wk	<b>CP</b> 6
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous Knowledge	Object oriented programming; all     Introduction to control systems     Control systems theory and desire	_	ructures	
Educational Objectives	LATTOR TAKING NART CHICCOCCTIHIV CTHICONTC	have reached the foll	owing learn	ing results
Professional Competence				
Knowledge	<ul> <li>Students can explain humanoid r</li> <li>Students can explain the basi forward- and inverse kinematics</li> <li>Students learn to apply basic cor robotics.</li> </ul>	c concepts, relation	•	
Skills	<ul> <li>Students can implement models C++, and use these models for re</li> <li>They are capable of using mode models if necessary with C++ co</li> <li>They are capable of selecting which no standard methods are a</li> </ul>	obot motion or other Is in Matlab for simul de on the real robot s methods for solving	tasks. ation and t system. abstract p	esting these
Personal Competence				
Social Competence	<ul> <li>Students can develop joint solution</li> <li>They can provide appropriate feedback on their own results</li> </ul>			
Autonomy	<ul> <li>Students are able to obtain reconstructions.</li> <li>They can independently define solve them.</li> </ul>	ntext of the lecture.	·	
Workload in Hours	Independent Study Time 96, Study Time	e in Lecture 84		
Credit points	6			
Course achievement	None			
	Written elaboration			
Examination duration and scale	5-10 pages			
	Computer Science: Specialisation II: Inte Mechatronics: Specialisation Intelligent Theoretical Mechanical Engineering: S	Systems and Robotic	s: Elective (	Compulsory

Assignment for	Elective Compulsory
the Following	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
Curricula	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory

Course L1794: Applied Humanoid Robotics		
Тур	Project-/problem-based Learning	
Hrs/wk	6	
СР	6	
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84	
Lecturer	Patrick Göttsch	
Language	DE/EN	
Cycle	WiSe/SoSe	
Content	<ul> <li>Fundamentals of kinematics</li> <li>Static and dynamic stability of humanoid robotic systems</li> <li>Combination of different software environments (Matlab, C++, etc.)</li> <li>Introduction to the necessary software frameworks</li> <li>Team project</li> <li>Presentation and Demonstration of intermediate and final results</li> </ul>	
Literature	<ul> <li>B. Siciliano, O. Khatib. "Handbook of Robotics. Part A: Robotics Foundations", Springer (2008)</li> </ul>	

Courses				
Courses		_		
Title Digital Signal Processis	ng and Digital Filters (L0446)	<b>Typ</b> Lecture	Hrs/wk 3	<b>CP</b> 4
		Recitation	Section 2	•
Digital Signal Processii	ng and Digital Filters (L0447)	(large)	2	2
Module Responsible	Prof. Gerhard Bauch			
Admission Requirements	None			
Recommended Previous Knowledge	<ul> <li>Fundamentals of signal and s</li> </ul>			
Educational Objectives	After taking part successfully, stude	ents have reached th	ne following learr	ning results
Professional Competence				
Knowledge	The students know and understar They are familiar with the spectral to describe and analyse signals and basic structures of digital filters a	transforms of discre I systems in time ar nd can identify and	ete-time signals nd image domair assess importar	and are ab i. They kno nt propertie
	coefficients and signals. They are can perform traditional and parame a limited observation window into a	familiar with the ba tric methods of spe- ccount.	sics of adaptive ctrum estimation	filters. The , also takir
Skills	The students are able to apply methods of digital signal processing to new problems. They can choose and parameterize suitable filter striuctures. In particular the can design adaptive filters according to the minimum mean squared error (MMSE) criterion and develop an efficient implementation, e.g. based on the LMS of RLS algorithm. Furthermore, the students are able to apply methods of spectrum estimation and to take the effects of a limited observation window into account.			
Personal Competence				
Social Competence	The students can jointly solve speci	fic problems.		
Autonomy	The students are able to acquire sources. They can control their lessolving tutorial problems, software	vel of knowledge o	luring the lectur	
Workload in Hours	Independent Study Time 110, Stud	Time in Lecture 70		
Credit points	6			
Course achievement	LNODE			
	Written exam			
Examination duration and scale				
	Electrical Engineering: Specialisat Elective Compulsory Computational Science and Engir Elective Compulsory Information and Communication S Focus Signal Processing: Elective Co	eering: Specialisat	ion II. Engineeri	ng Science

	Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory
Assignment for	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
the Following	Microelectronics and Microsystems: Specialisation Communication and Signal
Curricula	Processing: Elective Compulsory
	Microelectronics and Microsystems: Specialisation Communication and Signal
	Processing: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science:
	Elective Compulsory

Course L0446: Digi	ital Signal Processing and Digital Filters
Тур	Lecture
Hrs/wk	3
СР	
	Independent Study Time 78, Study Time in Lecture 42
Language	Prof. Gerhard Bauch
Cycle	
Content	<ul> <li>Transforms of discrete-time signals:         <ul> <li>Discrete-time Fourier Transform (DTFT)</li> <li>Discrete Fourier-Transform (DFT), Fast Fourier Transform (FFT)</li> <li>Z-Transform</li> </ul> </li> <li>Correspondence of continuous-time and discrete-time signals, sampling, sampling theorem</li> <li>Fast convolution, Overlap-Add-Method, Overlap-Save-Method</li> <li>Fundamental structures and basic types of digital filters</li> <li>Characterization of digital filters using pole-zero plots, important properties of digital filters</li> <li>Quantization effects</li> <li>Design of linear-phase filters</li> <li>Fundamentals of stochastic signal processing and adaptive filters         <ul> <li>MMSE criterion</li> <li>Wiener Filter</li> <li>LMS- and RLS-algorithm</li> </ul> </li> <li>Traditional and parametric methods of spectrum estimation</li> </ul>
Literature	<ul> <li>KD. Kammeyer, K. Kroschel: Digitale Signalverarbeitung. Vieweg Teubner.</li> <li>V. Oppenheim, R. W. Schafer, J. R. Buck: Zeitdiskrete Signalverarbeitung. Pearson StudiumA. V.</li> <li>W. Hess: Digitale Filter. Teubner.</li> <li>Oppenheim, R. W. Schafer: Digital signal processing. Prentice Hall.</li> <li>S. Haykin: Adaptive filter theory.</li> <li>L. B. Jackson: Digital filters and signal processing. Kluwer.</li> <li>T.W. Parks, C.S. Burrus: Digital filter design. Wiley.</li> </ul>

Course L0447: Digital Signal Processing and Digital Filters	
Тур	Recitation Section (large)
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Gerhard Bauch
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0629	9: Intelligent Autonomous	Agents and	l Cogi	nitive F	Robotics
Courses					
<b>Title</b> Intelligent Autonomous	s Agents and Cognitive Robotics (L0341) s Agents and Cognitive Robotics (L0512)	Typ Lecture Recitation (small)	Section	Hrs/wk 2 2	<b>CP</b> 4 2
Module Responsible	Rainer Marrone	(Siliali)			
Admission Requirements	None				
Recommended Previous Knowledge	Vectors, matrices, Calculus				
Educational Objectives	After taking part successfully, students	s have reached t	he follov	ving learn	ing results
Professional Competence					
Knowledge	Students can explain the agent abstrate behavior, and give details about agent can describe the main features of encooperation can be discussed in terms olving these problems. For dealing students can summarize how Bayesia representation and reasoning formaliss students can define decision making painted with and with complete access to the students can describe techniques for problems, and they can recall technical Students can identify techniques for can explain planning techniques for a coordination problems and decision different types of equilibria, social choods are considered.	t design (goals, nvironments. The ms of decision of the ms of the	utilities, e notion problem nty in be emple and environn to observating the states. ulti-ager	environm of adver s and alg real-world loyed as a settings. d sequent nent. In t able) Mark value of on and ma Students nt setting	nents). The sarial agen gorithms fo I scenarios a knowledge In addition cial settings his context kov decision information apping, and can explain in term o
Skills	Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilibria states,e.g., Nash equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results.				
Personal Competence	Students are able to discuss their	solutions to p	oroblem	s with o	thers. The
Social Competence	communicate in English				
	Students are able of checking their unvaraints of concrete problems	nderstanding of	complex	concepts	s by solving
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture 56	5		
Credit points	6				

achievement	None
Examination	Written exam
Examination duration and scale	90 minutes
	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

Course L0341: Inte	lligent Autonomous Agents and Cognitive Robotics
Тур	Lecture
Hrs/wk	2
СР	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	<ul> <li>Definition of agents, rational behavior, goals, utilities, environment types</li> <li>Adversarial agent cooperation:     Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of chance</li> <li>Uncertainty:     Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity, independence assumptions, naive Bayes, conditional independence assumptions</li> <li>Bayesian networks:     Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived).</li> <li>Probabilistic reasoning over time:     Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations</li> <li>Decision making under uncertainty:     Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio     Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs     Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks</li> <li>Simultaneous Localization and Mapping</li> <li>Planning</li> <li>Game theory (Golden Balls: Split or Share)     Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium</li> <li>Social Choice     Voting protocols, preferences, paradoxes, Arrow's Theorem,</li> <li>Mechanism Design     Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem, Direct mec</li></ul>
Literature	<ol> <li>Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17</li> <li>Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005</li> <li>Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009</li> </ol>

Course L0512: Intelligent Autonomous Agents and Cognitive Robotics		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Rainer Marrone	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0832	2: Advanced Topics in C	Control		
Courses				
<b>Title</b> Advanced Topics in Co Advanced Topics in Co		Typ Lecture Recitation	Hrs/wk 2 Section 2	<b>CP</b> 3
Module	Prof Herbert Werner	(small)		
Responsible Admission Requirements	<u> </u>			
Recommended	H-infinity optimal control, mixed-s	sensitivity design, line	ear matrix inequa	lities
Educational Objectives	After taking part successfully, stu	dents have reached t	the following lear	ning results
Professional Competence				
Knowledge	<ul> <li>Students can explain the ascheduling approach</li> <li>They can explain the repre LPV systems</li> <li>They can explain how stake can be formulated as LMI compared to the can explain how grides synthesis problems for LPV</li> <li>They are familiar with polysome of the basic synthesis structures</li> <li>Students can explain how communication topology of they can explain the comprotocols</li> <li>They can explain analysis as involving either LTI or LPV and the composition of the compositio</li></ul>	sentation of nonlinear polity and performance conditions ding techniques can systems systems stopic and LFT represt is techniques associal graph theoretic concern f multiagent systems sonvergence properties	r systems in the fire conditions for be used to solve tentations of LPV ated with each of the epts are used to respond to the epts of the first order	form of quasi LPV systems analysis and systems and these model represent the
	<ul> <li>Students can explain the distributed systems that ar</li> <li>They can explain (in outli such distributed systems distributed controllers</li> </ul>	e discretized accordine) the extension of	ng to an actuator f the bounded re	/sensor array al lemma to
Skills	<ul> <li>Students are capable of carry out a mixed-sensitiv do this using polytopic, LFT</li> <li>They are able to use stand for these tasks</li> </ul>	ity design of gain-sc or general LPV mode	heduled controlleels	ers; they car
5.3.75	<ul> <li>Students are able to design agents with either LTI or LF</li> </ul>			
	[202]	1		

	<ul> <li>Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox</li> </ul>		
Personal Competence			
Social Competence	Students can work in small groups and arrive at joint results.		
	Students are able to find required information in sources provided (lecture notes,		
Autonomy	literature, software documentation) and use it to solve given problems.		
Autonomy			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Oral exam		
Examination duration and scale			
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory		

Course L0661: Adv	anced Topics in Control
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	<ul> <li>Linear Parameter-Varying (LPV) Gain Scheduling</li> <li>Linearizing gain scheduling, hidden coupling</li> <li>Jacobian linearization vs. quasi-LPV models</li> <li>Stability and induced L2 norm of LPV systems</li> <li>Synthesis of LPV controllers based on the two-sided projection lemma</li> <li>Simplifications: controller synthesis for polytopic and LFT models</li> <li>Experimental identification of LPV models</li> <li>Controller synthesis based on input/output models</li> <li>Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator</li> <li>Control of Multi-Agent Systems</li> <li>Communication graphs</li> <li>Spectral properties of the graph Laplacian</li> <li>First and second order consensus protocols</li> <li>Formation control, stability and performance</li> <li>LPV models for agents subject to nonholonomic constraints</li> <li>Application: formation control for a team of quadrotor helicopters</li> <li>Control of Spatially Interconnected Systems</li> <li>Multidimensional signals, I2 and L2 signal norm</li> <li>Multidimensional systems in Roesser state space form</li> <li>Extension of real-bounded lemma to spatially interconnected systems</li> <li>LMI-based synthesis of distributed controllers</li> <li>Spatial LPV control of spatially varying systems</li> <li>Applications: control of temperature profiles, vibration damping for an actuated beam</li> </ul>
Literature	<ul> <li>Werner, H., Lecture Notes "Advanced Topics in Control"</li> <li>Selection of relevant research papers made available as pdf documents via StudIP</li> </ul>

Course L0662: Advanced Topics in Control	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M088:	1: Mathematical Image	Processing		
Courses				
<b>Title</b> Mathematical Image P Mathematical Image P		Typ Lecture Recitation	Hrs/wk 3 Section 1	<b>CP</b> 4
Module	TPIOLIVIAIKO LIDODEI	(small)		
Responsible Admission	None			
Requirements				
Recommended Previous Knowledge	Analysis: partial derivatives     Linear Algebra: eigenvalues			tem
Educational Objectives		lents have reached	the following learn	ing results
Professional Competence				
Knowledge	<ul> <li>Students are able to</li> <li>characterize and compare d</li> <li>explain elementary method</li> <li>explain methods of image s</li> <li>sketch and interrelate basic</li> </ul>	s of image processir egmentation and re	gistration	
Skills	Students are able to  implement and apply eleme explain and apply modern n			
Personal Competence				
Social Competence	Students are able to work together from different study programs theoretical foundations.			
Autonomy	<ul> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
Workload in Hours	Independent Study Time 124, Stud	dy Time in Lecture 5	6	
Credit points	6			
Course achievement	INONE			
Examination	Oral exam			
Examination duration and scale	20 min			
	Bioprocess Engineering: Specialisa Compulsory Computer Science: Specialisation I Computational Science and Engin Compulsory Mechatronics: Technical Complema Mechatronics: Specialisation Intelli	II. Mathematics: Ele neering: Specialisat entary Course: Elect	ctive Compulsory ion III. Mathemati	cs: Elective

	Mechatronics: Specialisation System Design: Elective Compulsory
Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science:
	Elective Compulsory
	Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0991: Mathematical Image Processing	
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	WiSe
Content	<ul> <li>basic methods of image processing</li> <li>smoothing filters</li> <li>the diffusion / heat equation</li> <li>variational formulations in image processing</li> <li>edge detection</li> <li>de-convolution</li> <li>inpainting</li> <li>image segmentation</li> <li>image registration</li> </ul>
Literature	Bredies/Lorenz: Mathematische Bildverarbeitung

Course L0992: Mathematical Image Processing	
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

	2: Technical Elective Course for TMBMS (according to fic Regulations)
Courses	
Title	Typ Hrs/wk CP
itcopolisibic	
Admission Requirements	None
Recommended Previous Knowledge	see FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
SKIIIS Personal	see FSPO
Competence	
Social Competence	
Autonomy	see FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
the Following	Compulsory Theoretical Machanical Engineering: Specialisation Energy Systems: Floativ

## **Specialization Simulation Technology**

Module M0603	3: Nonlinear Structural A	Analysis		
Courses				
<b>Title</b> Nonlinear Structural A	nalysis (L0277)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 4
Nonlinear Structural A	nalysis (L0279)	Recitation (small)	Section 1	2
Module Responsible	IPIOL Alexander Duster			
Admission Requirements	INONE			
Recommended Previous Knowledge	Knowledge of partial differential eq	uations is recommer	nded.	
Educational Objectives	After taking part successfully, stud	ents have reached th	ne following learn	ing results
Professional Competence				
Knowledge	Students are able to + give an overview of the different nonlinear phenomena in structural mechanics. + explain the mechanical background of nonlinear phenomena in structural mechanics. + to specify problems of nonlinear structural analysis, to identify them in a given situation and to explain their mathematical and mechanical background.			
Skills	Students are able to + model nonlinear structural problems. + select for a given nonlinear structural problem a suitable computational procedure. + apply finite element procedures for nonlinear structural analysis. + critically verify and judge results of nonlinear finite elements. + to transfer their knowledge of nonlinear solution procedures to new problems.			
Personal Competence				
Social Competence	Students are able to + solve problems in heterogeneous		locument the co	orresponding
Autonomy	Students are able to + acquire independently knowledg	e to solve complex p	roblems.	
<b>Workload in Hours</b>	Independent Study Time 124, Stud	y Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 min			
	Civil Engineering: Specialisation St	ructural Engineering:	Elective Compul	lsory

	International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory			
	aterials Science: Specialisation Modeling: Elective Compulsory			
	Mechatronics: Specialisation System Design: Elective Compulsory			
	Product Development, Materials and Production: Core qualification: Elective			
the Following	Compulsory			
Curricula	Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory			
	Ship and Offshore Technology: Core qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective			
	Compulsory			
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective			
	Compulsory			

Course L0277: Nonlinear Structural Analysis		
Тур	Lecture	
Hrs/wk	3	
СР	4	
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Alexander Düster	
Language	DE/EN	
Cycle	WiSe	
Content	<ol> <li>Introduction</li> <li>Nonlinear phenomena</li> <li>Mathematical preliminaries</li> <li>Basic equations of continuum mechanics</li> <li>Spatial discretization with finite elements</li> <li>Solution of nonlinear systems of equations</li> <li>Solution of elastoplastic problems</li> <li>Stability problems</li> <li>Contact problems</li> </ol>	
Literature	<ol> <li>Alexander Düster, Nonlinear Structrual Analysis, Lecture Notes, Technische Universität Hamburg-Harburg, 2014.</li> <li>Peter Wriggers, Nonlinear Finite Element Methods, Springer 2008.</li> <li>Peter Wriggers, Nichtlineare Finite-Elemente-Methoden, Springer 2001.</li> <li>Javier Bonet and Richard D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press, 2008.</li> </ol>	

Course L0279: Nonlinear Structural Analysis	
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Alexander Düster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1151	L: Material Modeling				
Courses					
<b>Title</b> Material Modeling (L15 Material Modeling (L15		Typ Lecture Recitation (small)	Section	Hrs/wk 2 2	<b>CP</b> 3
Module	Prof. Christian Cyron	(Siliali)			
Admission Requirements	None				
Recommended Previous Knowledge	Basics of linear and nonlinear continuum Mechanics II and Continuum Mechanics nonlinear strain, free-body principle, line energy)	(forces and	momen	ts, stress,	linear and
Educational Objectives	After taking part successfully, students h	ave reached t	he follow	ving learn	ing results
Professional Competence					
Knowledge	The students can explain the fundament	als of multidin	nensiona	al consitut	ive material
Skills	The students can implement their own particular, the students can apply their science and evaluate the corresponding i	knowledge to	various		
Personal Competence					
Social Competence	The students are able to develop solution develop ideas further.	ons, to prese	nt them	to specia	lists and to
Autonomy	The students are able to assess their of independently and on their own identify modeling and acquire the knowledge req	and solve prol	blems in		
Workload in Hours	Independent Study Time 124, Study Time	n I ecture 5	<u> </u>		
Credit points		on Lecture 5	<u> </u>		
Course achievement					
Examination	Written exam				
Examination duration and scale	45 min				
the Following	Materials Science: Specialisation Modelin Mechanical Engineering and Manage Compulsory Biomedical Engineering: Specialisation A Elective Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation I Elective Compulsory	ment: Specia rtificial Organ Implants ar Medical Tech	alisation s and Re nd Endo inology	Material egenerative prosthese and Cont	e Medicine: es: Elective rol Theory:

Product Development, Materials and Production: Core qualification: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L1535: Mate	erial Modeling
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	One of the most important questions when modeling mechanical systems in practice is how to model the behavior of the materials of their different components. In addition to simple isotropic elasticity in particular the following phenomena play key roles  - anisotropy (material behavior depending on direction, e.g., in fiber-reinforced materials)  - plasticity (permanent deformation due to one-time overload, e.g., in metal forming)  - viscoelasticity (absorption of energy, e.g., in dampers)  - creep (slow deformation under permanent load, e.g., in pipes)  This lecture briefly introduces the theoretical foundations and mathematical modeling of the above phenomena. It is complemented by exercises where simple examples problems are solved by calculations and where the implementation of the content of the lecture in computer simulations is explained. It will also briefly discussed how important material parameters can be determined from experimental data.
Literature	

Course L1536: Material Modeling	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0906	6: Numerical Simulation and	d Lagrang	ian Tr	anspo	rt
Courses					
	n turbulent flows (L2301) ynamics - Exercises in OpenFoam (L1375)	Typ Lecture Recitation (small)	Section	Hrs/wk 2 1	<b>CP</b> 3
Computational Fluid Dy	ynamics in Process Engineering (L1052)	Lecture		2	2
Module Responsible	Prof. Michael Schlüter				
Admission Requirements	None				
Recommended Previous Knowledge	<ul> <li>Basic knowledge in Fluid Mechani</li> </ul>				
Educational Objectives	After taking part successfully, students	have reached t	the follov	ving learn	ing results
Professional Competence	1 1				
Knowledge	<ul> <li>After successful completion of the modu</li> <li>explain the the basic principles simple systems)</li> <li>describe the main approaches in Molecular Dynamics) in various e</li> <li>discuss examples of computer proexists evaluate the application of numeror list the possible start and bounda</li> </ul>	of statistical n classical Mole nsembles ograms in deta rical simulation	thermod ecular Mo ail, as,	ynamics odeling (N	lonte Carlo,
Skills	<ul> <li>set up computer programs for set up computer programs for set up a numerical grid,</li> <li>perform a simple numerical simulate evaluate the result of a numerical</li> </ul>	deling, lation with Ope		ns by Mor	nte Carlo or
Personal Competence	1 1				
Social Competence	<ul> <li>The students are able to</li> <li>develop joint solutions in mixed t students,</li> <li>to collaborate in a team and to re</li> </ul>	•			
Autonomy	The students are able to:  • evaluate their learning progress on that basis, • evaluate possible consequences for the students are able to:	for their profes	sion.	ving steps	s of learning
Workload in Hours	Independent Study Time 110, Study Tim	ne in Lecture 7	0		

avT	Lecture
Hrs/wk	
СР	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Alexandra von Kameke
Language	EN
Cycle	
	Contents
	- Common variables and terms for characterizing turbulence (energy spectra energy cascade, etc.)
	- An overview of Lagrange analysis methods and experiments in fluid mechanics
	- Critical examination of the concept of turbulence and turbulent structures.
	-Calculation of the transport of ideal fluid elements and associated analysis method (absolute and relative diffusion, Lagrangian Coherent Structures, etc.)
	- Implementation of a Runge-Kutta 4th-order in Matlab
	- Introduction to particle integration using ODE solver from Matlab
	- Problems from turbulence research
	- Application analytical methods with Matlab.
	Structure:
	- 14 units a 2x45 min.
	- 10 units lecture

- 4 Units Matlab Exercise- Go through the exercises Matlab, Peer2Peer? Explain solutions to your colleague

## Content

Learning goals:

Students receive very specific, in-depth knowledge from modern turbulence research and transport analysis. → Knowledge

The students learn to classify the acquired knowledge, they study approaches to further develop the knowledge themselves and to relate different data sources to each other. → Knowledge, skills

The students are trained in the personal competence to independently delve into and research a scientific topic. → Independence

Matlab exercises in small groups during the lecture and guided Peer2Peer discussion rounds train communication skills in complex situations. The mixture of precise language and intuitive understanding is learnt. → Knowledge, social competence

Required knowledge:

Fluid mechanics 1 and 2 advantageous

Programming knowledge advantageous

Bakunin, Oleg G. (2008): Turbulence and Diffusion. Scaling Versus Equations. Berlin [u. a.]: Springer Verlag.

Bourgoin, Mickaël; Ouellette, Nicholas T.; Xu, Haitao; Berg, Jacob; Bodenschatz, Eberhard (2006): The role of pair dispersion in turbulent flow. In: Science (New York, N.Y.) 311 (5762), S. 835-838. DOI: 10.1126/science.1121726.

Davidson, P. A. (2015): Turbulence. An introduction for scientists and engineers. Second edition. Oxford: Oxford Univ. Press.

Graff, L. S.; Guttu, S.; LaCasce, J. H. (2015): Relative Dispersion in the Atmosphere from Reanalysis Winds. In: J. Atmos. Sci. 72 (7), S. 2769-2785. DOI: 10.1175/JAS-D-14-0225.1.

Grigoriev, Roman (2011): Transport and Mixing in Laminar Flows. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA.

Haller, George (2015): Lagrangian Coherent Structures. In: Annu. Rev. Fluid Mech. 47 (1), S. 137-162. DOI: 10.1146/annurev-fluid-010313-141322.

Kameke, A. von; Huhn, F.; Fernández-García, G.; Muñuzuri, A. P.; Pérez-Muñuzuri, V. (2010): Propagation of a chemical wave front in a quasi-two-dimensional superdiffusive flow. In: Physical review. E, Statistical, nonlinear, and soft matter physics 81 (6 Pt 2), S. 66211. DOI: 10.1103/PhysRevE.81.066211.

Kameke, A. von; Huhn, F.; Fernández-García, G.; Muñuzuri, A. P.; Pérez-Muñuzuri, V. (2011): Double cascade turbulence and Richardson dispersion in a horizontal fluid flow induced by Faraday waves. In: Physical review letters 107 (7), S. 74502. DOI: 10.1103/PhysRevLett.107.074502.

Literature Kameke, A.v.; Kastens, S.; Rüttinger, S.; Herres-Pawlis, S.; Schlüter, M. (2019): How coherent structures dominate the residence time in a bubble wake: An experimental example. In: Chemical Engineering Science 207, S. 317-326. 10.1016/j.ces.2019.06.033.

Klages, Rainer; Radons, Günter; Sokolov, Igor M. (2008): Anomalous Transport: Wiley.

LaCasce, J. H. (2008): Statistics from Lagrangian observations. In: Progress in Oceanography 77 (1), S. 1-29. DOI: 10.1016/j.pocean.2008.02.002.

Neufeld, Zoltán; Hernández-García, Emilio (2009): Chemical and Biological Processes in Fluid Flows: PUBLISHED BY IMPERIAL COLLEGE PRESS AND DISTRIBUTED BY WORLD SCIENTIFIC PUBLISHING CO.

Onu, K.; Huhn, F.; Haller, G. (2015): LCS Tool: A computational platform for Lagrangian coherent structures. In: Journal of Computational Science 7, S. 26-36. DOI: 10.1016/j.jocs.2014.12.002.

Ouellette, Nicholas T.; Xu, Haitao; Bourgoin, Mickaël; Bodenschatz, Eberhard (2006): An experimental study of turbulent relative dispersion models. In: New J. Phys. 8 (6), S. 109. DOI: 10.1088/1367-2630/8/6/109.

Pope, Stephen B. (2000): Turbulent Flows. Cambridge: Cambridge University Press.

Rivera, M. K.; Ecke, R. E. (2005): Pair dispersion and doubling time statistics in two-dimensional turbulence. In: Physical review letters 95 (19), S. 194503. DOI: 10.1103/PhysRevLett.95.194503.

Vallis, Geoffrey K. (2010): Atmospheric and oceanic fluid dynamics. Fundamentals and large-scale circulation. 5. printing. Cambridge: Cambridge Univ. Press.

Course L1375: Computational Fluid Dynamics - Exercises in OpenFoam		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Michael Schlüter	
Language	EN	
Cycle	SoSe	
Content	<ul> <li>generation of numerical grids with a common grid generator</li> <li>selection of models and boundary conditions</li> <li>basic numerical simulation with OpenFoam within the TUHH CIP-Pool</li> </ul>	
Literature	OpenFoam Tutorials (StudIP)	

Course L1052: Com	nputational Fluid Dynamics in Process Engineering
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	<ul> <li>Introduction into partial differential equations</li> <li>Basic equations</li> <li>Boundary conditions and grids</li> <li>Numerical methods</li> <li>Finite difference method</li> <li>Finite volume method</li> <li>Time discretisation and stability</li> <li>Population balance</li> <li>Multiphase Systems</li> <li>Modeling of Turbulent Flows</li> <li>Exercises: Stability Analysis</li> <li>Exercises: Example on CFD - analytically/numerically</li> </ul>
Literature	Paschedag A.R.: CFD in der Verfahrenstechnik: Allgemeine Grundlagen und mehrphasige Anwendungen, Wiley-VCH, 2004 ISBN 3-527-30994-2.  Ferziger, J.H.; Peric, M.: Numerische Strömungsmechanik. Springer-Verlag, Berlin, 2008, ISBN: 3540675868.  Ferziger, J.H.; Peric, M.: Computational Methods for Fluid Dynamics. Springer, 2002, ISBN 3-540-42074-6

Module M060	5: Computational Structu	ral Dynamic	S	
Courses				
<b>Title</b> Computational Structu Computational Structu	-	<b>Typ</b> Lecture Recitation	Hrs/wk 3 Section 1	<b>CP</b> 4
- Computational Structu		(small)		
Module Responsible	Prof. Alexander Duster			
Admission Requirements	LNODE			
Recommended Previous Knowledge	Knowledge of partial differential equa	ations is recommo	ended.	
Educational Objectives	After taking part successfully, studen	ts have reached	the following learr	ning results
Professional				
<b>Competence</b> <i>Knowledge</i>	Students are able to + give an overview of the comput dynamics.	ement programs	to solve problems	of structura
Skills	given situation and to explain their model problems of structural dyna + select a suitable solution procedures to + verify and critically judge results or	mics. e for a given prob solve problems	olem of structural of structural of structural dynar	dynamics. nics.
Personal				
Competence Social Competence	Students are able to	s groups and to	document the co	orresponding
Autonomy	Students are able to + acquire independently knowledge	to solve complex	problems.	
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 5	6	
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2h			
Assignment for the Following Curricula	International Management and Engin Compulsory Materials Science: Specialisation Mod Mechatronics: Technical Complement Naval Architecture and Ocean Engine	leling: Elective Co tary Course: Elec eering: Core quali	ompulsory tive Compulsory fication: Elective C	Compulsory

Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0282: Computational Structural Dynamics		
Тур	Lecture	
Hrs/wk	3	
СР	4	
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Alexander Düster	
Language	DE	
Cycle	SoSe	
Content	<ol> <li>Motivation</li> <li>Basics of dynamics</li> <li>Time integration methods</li> <li>Modal analysis</li> <li>Fourier transform</li> <li>Applications</li> </ol>	
Literature	[1] KJ. Bathe, Finite-Elemente-Methoden, Springer, 2002. [2] J.L. Humar, Dynamics of Structures, Taylor & Francis, 2012.	

Course L0283: Com	Course L0283: Computational Structural Dynamics		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Alexander Düster		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0653	3: High-Performance Com	puting		
Courses				
Title		Тур	Hrs/wk	СР
Fundamentals of High-	Performance Computing (L0242)	Lecture	2	3
Fundamentals of High-	Performance Computing (L1416)	Project-/problem- based Learning	2	3
Module Responsible	Prof. Thomas Rung			
Admission Requirements	INONE			
Recommended Previous Knowledge	Basic knowledge in usage of m     Programming skills	nodern IT environment		
Educational Objectives	After taking part successfully, studen	ts have reached the fol	lowing learn	ing results
Professional				
Competence				
Knowledge	Students are able to outline the fundamentals of numerical algorithms for high- performance computers by reference to modern hardware examples. Students can explain the relation between hard- and software aspects for the design of algorithms.			
Skills	Student can perform a critical assesment of the computational efficiency of simulation approaches.			
Personal				
Competence		lo algorithms in a toam		
•	Students are able to develop and code algorithms in a team.			
Autonomy				
	Independent Study Time 124, Study	Time in Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
the Following	Naval Architecture and Ocean Engine Theoretical Mechanical Engineering Compulsory Theoretical Mechanical Engineering: Compulsory	: Technical Compleme	ntary Cour	se: Elective

Course L0242: Fundamentals of High-Performance Computing		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Thomas Rung	
Language	DE/EN	
Cycle	SoSe	
Content	Fundamentals of modern hardware architectur, critical hard- & software aspects for efficient processing of exemplary algorithms, concepts for shared- and distributed-memory systems, implementations for accelerator hardware (GPGPUs)	
Literature	1) Vortragsmaterialien und Problemanleitungen  2) G. Hager G. Wellein: Introduction to High Performance Computing for Scientists and Engineers CRC Computational Science Series, 2010	

Course L1416: Fundamentals of High-Performance Computing		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Thomas Rung	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0606	6: Numerical Algorithms i	in Structural	Mechanics	
Courses				
Title  Numerical Algorithms in Structural Mechanics (L0284)  Numerical Algorithms in Structural Mechanics (L0285)		<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3
Module Responsible	I Prof. Alayandar i liletar	(Siliali)		
Admission Requirements				
Recommended Previous Knowledge	Knowledge of partial differential equ	ations is recomme	nded.	
Educational Objectives	After taking part successfully, stude	nts have reached t	he following learn	ing results
Professional Competence				
Knowledge	Students are able to + give an overview of the standard algorithms that are used in finite element programs. + explain the structure and algorithm of finite element programs. + specify problems of numerical algorithms, to identify them in a given situation and to explain their mathematical and computer science background.			
Skills	Students are able to + construct algorithms for given numerical methods. + select for a given problem of structural mechanics a suitable algorithm. + apply numerical algorithms to solve problems of structural mechanics. + implement algorithms in a high-level programming languate (here C++). + critically judge and verfiy numerical algorithms.			
Personal Competence				
Social Competence	Students are able to + solve problems in heterogeneou results.	s groups and to	document the co	orresponding
Autonomy	Students are able to + acquire independently knowledge	to solve complex	problems.	
	Independent Study Time 124, Study	Time in Lecture 5	<u> </u>	
Credit points				
Course achievement	None			
Examination				
Examination duration and scale				
the Following	Materials Science: Specialisation Modeling: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory			

Course L0284: Numerical Algorithms in Structural Mechanics		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Düster	
Language	DE	
Cycle	SoSe	
Content	<ol> <li>Motivation</li> <li>Basics of C++</li> <li>Numerical integration</li> <li>Solution of nonlinear problems</li> <li>Solution of linear equation systems</li> <li>Verification of numerical algorithms</li> <li>Selected algorithms and data structures of a finite element code</li> </ol>	
Literature	[1] D. Yang, C++ and object-oriented numeric computing, Springer, 2001. [2] KJ. Bathe, Finite-Elemente-Methoden, Springer, 2002.	

Course L0285: Nun	Course L0285: Numerical Algorithms in Structural Mechanics		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Alexander Düster		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses					
<b>Title</b> Boundary Element Met	thods (L0523)		<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3
Boundary Element Met	thods (L0524)		Recitation (large)	Section 2	3
Module Responsible					
Admission Requirements	LNODE				
Recommended Previous Knowledge	Kinematics, Dynamics)				Hydrostatics
Educational Objectives	LATTEL TAKING DALL SUCCE	ssfully, students h	nave reached t	the following learr	ning results
Professional Competence					
Knowledge	The students possess boundary element met methodical basis of the	thod and are able			
Skills	The students are capa boundary elements, as resulting system of equ	sembling the corr			
Personal Competence	Ctudents can week in a	mall groups on sp	ecific problem	s to arrive at joint	solutions
Social Competence	The students are able and develop own bour results are critically scr	to independently	· · solve challer	nging computation	nal problem
Autonomy	_	utilized.			
Workload in Hours	Independent Study Tim	ne 124, Study Tim	e in Lecture 5	6	
Credit points	6				
Course achievement	CompulsorBonus No 20 %	<b>Form</b> Midterm	D	escription	
Examination	Written exam				
Examination duration and scale	90 min				
	Civil Engineering: Spec Civil Engineering: Spec Civil Engineering: Spec	ialisation Geotech	nnical Enginee	ring: Elective Com	pulsory

	Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective
Curricula	Product Development, Materials and Production: Core qualification: Elective Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0523: Boundary Element Methods		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Otto von Estorff	
Language	EN	
Cycle	SoSe	
Content	<ul> <li>Boundary value problems</li> <li>Integral equations</li> <li>Fundamental Solutions</li> <li>Element formulations</li> <li>Numerical integration</li> <li>Solving systems of equations (statics, dynamics)</li> <li>Special BEM formulations</li> <li>Coupling of FEM and BEM</li> <li>Hands-on Sessions (programming of BE routines)</li> <li>Applications</li> </ul>	
Literature	Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin	

Course L0524: Boundary Element Methods		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Otto von Estorff	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0716	6: Hierarchical Algorithms			
Courses				
<b>Title</b> Hierarchical Algorithm:		Typ Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3
Module Responsible	Prof. Sabine Le Borne	(3.1.0.1.)		
Admission Requirements	None			
Recommended Previous Knowledge	& Linear Algebra I + II as well as			
Educational Objectives	After taking part successfully, students	s have reached	the following lear	ning results
Professional Competence	Students are able to			
Knowledge	<ul> <li>name representatives of hierarc</li> <li>explain construction techniques</li> <li>discuss aspects regarding th algorithms.</li> </ul>	for hierarchica	l algorithms,	
Skills	Students are able to  implement the hierarchical algo analyse the storage and comput adapt algorithms to problem develop problem adapted variar	tational comple settings of v	xities of the algor	
Personal Competence	Students are able to			
Social Competence	<ul> <li>work together in heterogene different study programs and foundations and support each implementation of algorithms.</li> </ul>	background k	nowledge), explai	n theoretica
Autonomy	to assess whether the support better solved individually or in a       to work on complex problems over the total t	i team, ver an extende	d period of time,	
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture !	56	
Credit points	6			
Course achievement	INONE			
Examination	Oral exam			
Examination duration and scale				
-	1			

Assignment for the Following	Computer Science: Specialisation III. Mathematics: Elective Compulsory Mathematical Modelling in Engineering: Theory, Numerics, Applications: Specialisation II. Modelling and Simulation of Complex Systems (TUHH): Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0585: Hierarchical Algorithms			
<b>Typ</b> Lecture			
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	<b>Lecturer</b> Prof. Sabine Le Borne		
Language	Language DE/EN		
Cycle	Cycle WiSe		
Content	<ul> <li>Low rank matrices</li> <li>Separable expansions</li> <li>Hierarchical matrix partitions</li> <li>Hierarchical matrices</li> <li>Formatted matrix operations</li> <li>Applications</li> <li>Additional topics (e.g. H2 matrices, matrix functions, tensor products)</li> </ul>		
Literature	<b>Literature</b> W. Hackbusch: Hierarchische Matrizen: Algorithmen und Analysis		

Course L0586: Hierarchical Algorithms		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Sabine Le Borne	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1020	0: Numerics of Partial Dif	ferential Equ	uations	
Courses				
	ferential Equations (L1247) ferential Equations (L1248)	<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3
Module Responsible	IPM Damer Kilorem			
Admission Requirements	None			
Recommended Previous Knowledge	Il for Technomathematicians  • Numerical mathematics 1	_	•	Algebra I +
Educational Objectives	After taking part successfully, stude	nts have reached t	the following learn	ing results
Professional Competence				
Knowledge	<ul> <li>Students can classify partial basic types.</li> <li>For each type, students know</li> <li>Students know the theoretica</li> </ul>	suitable numerica	l approaches.	
Skills	Students are capable to formulate partial differential equations, to convergence and to implement and	omment on theo	retical properties	
Personal Competence				
Social Competence	Students are able to work together i from different study programs theoretical foundations.			
Autonomy	<ul> <li>Students are capable of check their own. They can specify of help in solving them.</li> <li>Students have developed sufficient periods in a goal-oriented ma</li> </ul>	ppen questions pre ficient persistence	cisely and know verto be able to wo	vhere to get
<b>Workload in Hours</b>	Independent Study Time 124, Study	Time in Lecture 5	6	
Credit points	<u> </u>			
Course achievement	None			
Examination	<u> </u>			
Examination duration and scale	25 min			
	Computer Science: Specialisation III. Technomathematics: Specialisation Theoretical Mechanical Engineering Compulsory Theoretical Mechanical Engineering: Elective Compulsory Theoretical Mechanical Engineering	I. Mathematics: Eleg: Technical Com	ective Compulsory plementary Cours merics and Compu	se: Elective iter Science:

Compulsory

Course L1247: Numerics of Partial Differential Equations		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	NN	
Language	DE/EN	
Cycle	WiSe	
Content	<ul> <li>Elementary Theory and Numerics of PDEs</li> <li>types of PDEs</li> <li>well posed problems</li> <li>finite differences</li> <li>finite elements</li> <li>finite volumes</li> <li>applications</li> </ul>	
Literature	Dietrich Braess: Finite Elemente: Theorie, schnelle Löser und Anwendungen in der Elastizitätstheorie, Berlin u.a., Springer 2007 Susanne Brenner, Ridgway Scott: The Mathematical Theory of Finite Element Methods, Springer, 2008 Peter Deuflhard, Martin Weiser: Numerische Mathematik 3	

Course L1248: Numerics of Partial Differential Equations		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	NN	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature See interlocking course		

Courses					
<b>Title</b> Matrix Algorithms (L09			<b>Typ</b> Lecture Recitation	Hrs/wk 2 Section 2	<b>CP</b> 3
Matrix Algorithms (L09	85)		(small)	2	3
Module Responsible	Dr. je	ns-Peter Zemke			
Admission Requirements	None				
Recommended Previous Knowledge	•	Mathematics I - III Numerical Mathematics 1/ Basic knowledge of the pro		: Matlab and C	
Educational Objectives	After	taking part successfully, stu	dents have reached t	he following lear	ning results
Professional Competence					
Knowledge	1. 2.	name, state and classify solution of the core preigenvalue problems, solut state approaches for the state approaches for the sents are capable to	oblems of the englion of linear systems	gineering sciend , and model redu	ces, namel iction;
Skills	2.	implement and assess ba eigenvalue problems, linea assess methods used in r stability, and domain of ap adapt the approaches learn	r systems, and mode nodern software with olicability;	I reduction; n respect to con	nputing tim
Personal Competence					
	Stude	ents can			
Social Competence	•	develop and document join form groups to further dev applicability; form a team to develop, bu	elop the ideas and tr	ansfer them to o	other areas
Autonomy	•	correctly assess the time a assess whether the suppor solved individually or in a t define test problems for te assess their individual pro help.	ting theoretical and រុ eam; sting and expanding :	oractical excercis	
		endent Study Time 124, Stu	dy Time in Lecture 5	6	
Credit points Course					
achievement Examination					

Examination duration and scale	
Assignment for the Following Curricula	

Course L0984: Mat	rix Algorithms
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	<ul> <li>Part A: Krylov Subspace Methods:         <ul> <li>Basics (derivation, basis, Ritz, OR, MR)</li> <li>Arnoldi-based methods (Arnoldi, GMRes)</li> <li>Lanczos-based methods (Lanczos, CG, BiCG, QMR, SymmLQ, PvL)</li> <li>Sonneveld-based methods (IDR, BiCGStab, TFQMR, IDR(s))</li> </ul> </li> <li>Part B: Matrix Equations:         <ul> <li>Sylvester Equation</li> <li>Lyapunov Equation</li> <li>Algebraic Riccati Equation</li> </ul> </li> </ul>
Literature	Skript

Course L0985: Mat	Course L0985: Matrix Algorithms			
Тур	Recitation Section (small)			
Hrs/wk	2			
СР	3			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Dr. Jens-Peter Zemke			
Language	DE/EN			
Cycle	WiSe			
Content				
Literature	Siehe korrespondierende Vorlesung			

Module M0658	3: Innovative CFD Approa	ches					
Courses							
Title		Тур	Hrs/wk	СР			
Application of Innovation Development (L0239)	ve CFD Methods in Research and	Lecture	2	3			
	ve CFD Methods in Research and	Recitation (small)	Section 2	3			
	Prof. Thomas Rung	, ,					
Admission Requirements	None						
Requirements		dynamics course (	CED1/CED2)				
	Competent knowledge of numer computational thermo/fluid dynamics	ical analysis in		eneral and			
Educational Objectives	After taking part successfully, studen	its have reached t	he following learr	ning results			
Professional Competence							
Knowledge	Student can explain the theoretical Lattice-Boltzmann, Smoothed Particle describe the fundamentals of simulat	e-Hydrodynamics,	Finite-Volume me				
Skills	Student is able to identify an approp basis.	riate CFD-based s	solution strategy o	on a jusitfied			
Personal Competence							
Social Competence	Student should practice her/his tean and present solutions to experts.	n-working abilities	s, learn to lead te	am sessions			
Autonomy	Student should be able to structi independently,	ure and perform	a simulation-ba	ased projec			
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 50	6				
Credit points	6						
Course achievement	CompulsorBonus Form Yes 20 % Written elabor		escription				
Examination	Oral exam						
Examination duration and scale							
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Ship and Offshore Technology: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory						

Course L0239: App	Course L0239: Application of Innovative CFD Methods in Research and Development					
Тур	Lecture					
Hrs/wk	2					
СР	3					
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28					
Lecturer	Prof. Thomas Rung					
Language	DE/EN					
Cycle	WiSe					
Content	Computational Optimisation, Parallel Computing, Efficient CFD-Procedures for GPU Archtiectures, Alternative Approximations (Lattice-Boltzmann Methods, Particle Methods), Fluid/Structure-Interaction, Modelling of Hybrid Continua					
Literature	Vorlesungsmaterialien /lecture notes					

Course L1685: App	Course L1685: Application of Innovative CFD Methods in Research and Development				
Тур	Recitation Section (small)				
Hrs/wk	2				
СР	3				
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28				
Lecturer	Prof. Thomas Rung				
Language	DE/EN				
Cycle	WiSe				
Content	See interlocking course				
Literature	See interlocking course				

Module M132	7: M	odelin	g of G	ranula	ar Mate	erials			
Courses									
Title Multiscale simulation of Multiscale simulation of	_					Typ Lecture Recitation (small)	Section	Hrs/wk 2	<b>CP</b> 2 2
Thermodynamic and k	inetic	modeling o	of the soli	d state (L	1859)	Lecture		2	2
Module Responsible	PIOI.	Maksym l	Dosta						
Admission Requirements	None	2							
Recommended Previous Knowledge	Fund	amentals	in Mathe	ematocs,	Physics a	nd Mechani	cs		
Educational Objectives	After	taking pa	art succe	ssfully, st	udents h	ave reached	I the follo	wing learn	ing results
Professional Competence									
Knowledge	•	describe granula analyze time an scale up list mode explain modelin list expe explain with sol explain	e moderr r materia and eva d length o to proce lern simu fundam ig of part erimenta fundame ids	n modelinals aluate po scales: fress simululation sy nentals of ciculate m I method ental the	ssibility to mession description on restem and formaterials to characterials remodynar	e the studer ches which o apply nur iption of sir macro scale discuss pos numerical acterize grai nic and kin d limitation	can be ap merical sir igle partic ssibility of methods nular mate etic relation	plied for s mulations le propert their appl which ar erials ons for th	on differenties on micro ication e used for e processes
Skills	•	perform dynamic simulate Element optimize crushing apply m evaluate select process	i flowshe c process e behavi t Method e proces g,) wit nultiscale e results and apl es with s	et simula s behavio ior of gra (DEM) ses of m h DEM simulatio of numer ply appr	ation of so ir anular ma echanica ons for ma rical simu opriate	e the studer olids process aterials on process en odeling of p lations thermodyna	the microngineering articulate	nalyze ster o scale w g (mixing, materials kinetic	separation
Personal Competence									
Social Competence	ques	complet tions in s ons and in	small te	ams to e	enhance		be able to take p	to debat	e technica their owr
	After	complet	ion of tl	his modu	ıle, partio	cipants will	be able	to solve	a technica

Autonomy	problem independently including a presentation of the results. They are able to work out the knowledge that is necessary to solve the problem by themselves on the basis of the existing knowledge from the lecture.
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Chemical and Bioprocess Engineering: Specialisation General Process Engineering:

Course L1858: Mul	tiscale simulation of granular materials
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Maksym Dosta
Language	EN
Cycle	WiSe
Content	<ul> <li>Steady-state flowsheet simulation of solids processes</li> <li>Dynamic flowsheet simulation of solids processes</li> <li>Introduction to Discrete Element Method (DEM)</li> <li>Contact and breakage mechanics of granular materials</li> <li>Extension of DEM</li> <li>Modeling of Gas/Solid streams with coupled DEM and CFD methods</li> <li>Population balance modelling of solids processes</li> <li>Multiscale simulation of particulate materials</li> </ul>
Literature	<ul> <li>B.V. Babu (2004). Process plant simulation, Oxford Univ. Press, New York.</li> <li>S.J. Antony, W. Hoyle, Y. Ding (Eds.) (2004). Granular materials: Fundamentals and Applications, RSC, Cambridge.</li> <li>T. Pöschel (2010). Computational Granular Dynamics: Models and Algorithms, Springer Verl. Berlin.</li> <li>Other lecture materials to be distributed</li> </ul>

Course L1860: Mult	tiscale simulation of granular materials
Тур	Recitation Section (small)
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Maksym Dosta
Language	EN
Cycle	WiSe
Content	<ul> <li>Introduction into simulation frameworks: Aspen Plus (Solids), Dyssol, MUSEN</li> <li>Steady-state flowsheet simulation of solids processes (Aspen Plus)</li> <li>Dynamic flowsheet simulation of solids processes (Dyssol)</li> <li>Implementation of new contact laws and calculation of particle interactions (Matlab)</li> <li>Simulation of granular materials with population balance models (Matlab)</li> <li>Simulation of granular materials with discrete element method (MUSEN)</li> <li>Optimization of several processes with discrete element method (MUSEN)</li> </ul>
Literature	<ul><li>M. Dosta: Lecture notes.</li><li>S. Attaway (2013). Matlab: A Practical Introduction to Programming and Problem Solving, Third Ed.</li><li>Other lecture materials to be distributed</li></ul>

Course L1859: The	rmodynamic and kinetic modeling of the solid state
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Pavel Gurikov
Language	EN
Cycle	WiSe
Content	<ul> <li>Thermodynamics of pure solids: melting/crystallization; glassy and amorphous state.</li> <li>Thermodynamics of solid-gas equilibria: adsorption and sublimation.</li> <li>Thermodynamics of solid-liquid equilibria: solubility in aqueous and non-aqueous systems; solid solutions; supercritical fluids as solvents.</li> <li>Kinetics of dissolution/precipitation processes: chemical vapor deposition; drug release; hydrothermal processes.</li> <li>Characterization of solids: contact angle, adsorption techniques, IR spectroscopy, electron microscopy.</li> <li>Discrete models of dissolution/precipitation processes: diffusion limited aggregation; random-like and ballistic-like deposition models</li> <li>Advanced discrete models: surface wettability; adsorption and precipitation of (bio)polymers.</li> </ul>
Literature	Prausnitz, J.M., Lichtenthaler, R.N., and Azevedo, E.G. de (1998). Molecular Thermodynamics of Fluid-Phase Equilibria, Pearson Education.  Elliott, S., and Elliott, S.R. (1998). The Physics and Chemistry of Solids, Wiley.  Chopard, B., and Droz, M. (2005). Cellular Automata Modeling of Physical Systems, Cambridge University Press.

	2: Technical Elective Course for TMBMS (according to fic Regulations)
Courses	
Title	Typ Hrs/wk CP
Module Responsible	Prof. Robert Seifried
Admission Requirements	
Recommended Previous Knowledge	see FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	see FSPO
Skills	see FSPO
Personal	
Competence	
Social Competence	
Autonomy	
	Depends on choice of courses
Credit points	
THE FAIINWING	

## **Supplement Modules**

Module Responsible   Admission   None   No	Courses					
Responsible Admission None Requirements Recommended Previous none Educational Objectives Professional Competence  Students can:  Describe the system configuration and components of the main clinic imaging systems; Explain how the system components and the overall system of the imaging systems function; Explain how the system components and the overall system of the imaging systems function; Explain and apply the physical processes that make imaging possible and us with the fundamental physical equations; Name and describe the physical effects required to generate imagiontrasts; Explain how spatial and temporal resolution can be influenced and how characterize the images generated; Explain which image reconstruction methods are used to generate images; Describe and explain the main clinical uses of the different systems.  Students are able to:  Explain the physical processes of images and assign to the systems the bas mathematical or physical equations required; Calculate the parameters of imaging systems using the mathematic or physical equations; Describe and temporal resolution of imaging systems on the spatiand temporal resolution of imaging systems for a number clinical applications; Select a suitable imaging system for an application.  Personal Competence Social Competence Social Competence  Once Students can:  Understand which physical effects are used in medical imaging; Decide independently for which clinical issue a measuring system can be used.		ms (L0819)				_
Recommended Previous Knowledge  Educational Objectives  Professional Competence  Students can:  Describe the system configuration and components of the main clinic imaging systems; Explain how the system components and the overall system of the imaging systems function; Explain and apply the physical processes that make imaging possible and us with the fundamental physical equations; Name and describe the physical effects required to generate imaging contrasts; Explain how spatial and temporal resolution can be influenced and how characterize the images generated; Explain which image reconstruction methods are used to generate images; Describe and explain the main clinical uses of the different systems.  Students are able to:  Explain the physical processes of images and assign to the systems the bas mathematical or physical equations; Calculate the parameters of imaging systems using the mathematic or physical equations; Describe and temporal resolution of imaging systems for a number clinical applications;  Select a suitable imaging system for an application.  Personal Competence  Social Competence  Social Competence  Fundamental or physical effects are used in medical imaging; Decide independently for which clinical issue a measuring system can be used.		Dr. Michael Gra	SS			
After taking part successfully, students have reached the following learning results		None				
Professional Competence  Students can:  Describe the system configuration and components of the main clinic imaging systems; Explain how the system components and the overall system of the imagin systems function; Explain and apply the physical processes that make imaging possible and us with the fundamental physical equations; Name and describe the physical effects required to generate imaging contrasts; Explain how spatial and temporal resolution can be influenced and how characterize the images generated; Explain which image reconstruction methods are used to generate images; Describe and explain the main clinical uses of the different systems.  Students are able to:  Explain the physical processes of images and assign to the systems the bas mathematical or physical equations required; Cocludate the parameters of imaging systems using the mathematic or physical equations; Determine the influence of different system components on the spatiand temporal resolution of imaging systems; Explain the importance of different imaging systems for a number clinical applications; Select a suitable imaging system for an application.  Personal Competence  Social Competence  Social Competence  Once  Students can:  Understand which physical effects are used in medical imaging; Decide independently for which clinical issue a measuring system can be used.	Previous	none				
Students can:  Describe the system configuration and components of the main clinic imaging systems; Explain how the system components and the overall system of the imaging systems function; Explain and apply the physical processes that make imaging possible and us with the fundamental physical equations; Name and describe the physical effects required to generate imaging contrasts; Explain how spatial and temporal resolution can be influenced and how characterize the images generated; Explain which image reconstruction methods are used to generate images; Describe and explain the main clinical uses of the different systems.  Students are able to:  Explain the physical processes of images and assign to the systems the basinathematical or physical equations required; Calculate the parameters of imaging systems using the mathematical or physical equations; Determine the influence of different system components on the spatiand temporal resolution of imaging systems; Determine the influence of different imaging systems for a number clinical applications; Select a suitable imaging system for an application.  Personal Competence Social Competence Social Competence  In Understand which physical effects are used in medical imaging; Understand which physical effects are used in medical imaging; Decide independently for which clinical issue a measuring system can be used.	Educational Objectives	After taking par	t successfully, studer	nts have reached th	e following learn	ing results
Describe the system configuration and components of the main clinic imaging systems;     Explain how the system components and the overall system of the imaging systems function;     Explain and apply the physical processes that make imaging possible and us with the fundamental physical equations;     Name and describe the physical effects required to generate imaging contrasts;     Explain how spatial and temporal resolution can be influenced and how characterize the images generated;     Explain which image reconstruction methods are used to generate images;     Describe and explain the main clinical uses of the different systems.  Students are able to:      Explain the physical processes of images and assign to the systems the base mathematical or physical equations;     Calculate the parameters of imaging systems using the mathematic or physical equations;     Determine the influence of different system components on the spatial and temporal resolution of imaging systems;     Explain the importance of different imaging systems for a number clinical applications;  Select a suitable imaging system for an application.  Personal Competence  Social Competence  Social Competence  Ounce Students can:  Understand which physical effects are used in medical imaging;     Decide independently for which clinical issue a measuring system can be used.						
Explain the physical processes of images and assign to the systems the base mathematical or physical equations required;     Calculate the parameters of imaging systems using the mathematic or physical equations;     Determine the influence of different system components on the spatiand temporal resolution of imaging systems;     Explain the importance of different imaging systems for a number clinical applications;  Select a suitable imaging system for an application.  Personal Competence  Social Competence  Students can:  Understand which physical effects are used in medical imaging; Decide independently for which clinical issue a measuring system can be used.	Knowledge	<ul> <li>Describe imaging</li> <li>Explain h systems</li> <li>Explain a with the</li> <li>Name a contrasts</li> <li>Explain h characte</li> <li>Explain v</li> </ul>	systems; ow the system completed function; and apply the physical fundamental physical describe the plus is a spatial and templeted fundamental physical fundamental physical describe the plus spatial and templeted fundamental fundamen	oonents and the over a processes that made of the control of the c	verall system of the imaging possing possing possing possing to generate used to generate	the imaginable and use the image and how the second
Competence Social Competence none Students can:  • Understand which physical effects are used in medical imaging; • Decide independently for which clinical issue a measuring system can be used.	Skills	<ul> <li>Explain t mathema</li> <li>Ca</li> <li>or</li> <li>De</li> <li>an</li> <li>cli</li> </ul>	ne physical processestical or physical equalical or physical equalicans; physical equations; termine the influenced temporal resolution plain the importance inical applications;	ations required; ers of imaging syster e of different syster n of imaging system e of different imagi	ems using the m m components o	nathematic
Social Competence Students can:  • Understand which physical effects are used in medical imaging; • Decide independently for which clinical issue a measuring system can be used.						
<ul> <li>Students can:</li> <li>Understand which physical effects are used in medical imaging;</li> <li>Decide independently for which clinical issue a measuring system can lused.</li> </ul>	- :	none				
Markland in Hours Independent Study Time 124. Study Time in Lecture 56		Students can:  • Understa • Decide i				tem can b
AND REPORT OF THE PROPERTY OF THE PROPERTY OF THE PARTY OF THE PROPERTY OF THE						

Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Product Nevelopment Materials and Production, Specialisation Materials, Flectivel

Course L0819: Med	lical Imaging Systems
Тур	Lecture
Hrs/wk	4
СР	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dr. Michael Grass, Dr. Tim Nielsen, Dr. Sven Prevrhal, Frank Michael Weber
Language	DE
Cycle	SoSe
Content	
	Primary book:
	1. P. Suetens, "Fundamentals of Medical Imaging", Cambridge Press
	Secondary books:
	- A. Webb, "Introduction to Biomedical Imaging", IEEE Press 2003.
Literature	- W.R. Hendee and E.R. Ritenour, "Medical Imaging Physics", Wiley-Liss, New York, 2002.
	- H. Morneburg (Edt), "Bildgebende Systeme für die medizinische Diagnostik", Erlangen: Siemens Publicis MCD Verlag, 1995.
	- O. Dössel, "Bildgebende Verfahren in der Medizin", Springer Verlag Berlin, 2000.

Module M0630	0: Robotics and	Navigation i	n Medicine		
_					
Courses					
Title	on in Madiaina (LOZZE)		Typ	Hrs/wk	CP
_	on in Medicine (L0335) on in Medicine (L0338)		Lecture Project Seminar	2 2	3 2
_	on in Medicine (L0336)		Recitation Section (small)	<sup>n</sup> 1	1
Module Responsible	TPINI DIEXANNEI SCHIAF	efer			
Admission Requirements	None				
Recommended Previous Knowledge	<ul> <li>principles of pro</li> </ul>	ath (algebra, analys ogramming, e.g., in b skills			
Educational Objectives	After taking part succe	essfully, students h	ave reached the follo	owing learn	ing results
Professional					
Competence	<u> </u>				
Knowledge	The students can exp illustrate systems and respect to collision d typical systems regard	d their components letection and saf	s in detail. Systems ety and regulations	can be eva	aluated with
Skills	The students are ab systems for medical a		evaluate navigation	systems	and robotio
Personal Competence					
Social Competence	The students discuss incoorporate feedback		r groups, provide he	lpful feedb	ack and car
Autonomy	The students can refl They can present the			e results o	f their work
Workload in Hours	Independent Study Tir	ne 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	10 %	<b>Form</b> Written elaborati Presentation	<b>Descrip</b> on	tion	
Examination	Written exam				
Examination duration and scale	90 minutes				
	Computer Science: Sp Electrical Engineering: International Manager Elective Compulsory International Manager and Biotechnology: Ele Mechatronics: Special Biomedical Engineerin Elective Compulsory Biomedical Engineeri	E Specialisation Med ment and Engineeri ment and Engineer ective Compulsory isation Intelligent S ag: Specialisation A	dical Technology: Ele ng: Specialisation II. ring: Specialisation ystems and Robotics rtificial Organs and I	ctive Comp Electrical I II. Process s: Elective C Regenerativ	oulsory Engineering Engineering Compulsory ve Medicine

the Following	Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
Curricula	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory Product Development, Materials and Production: Specialisation Product
	Development: Elective Compulsory
	Product Development, Materials and Production: Specialisation Production: Elective
	Compulsory
	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology:
	Elective Compulsory

Course L0335: Robotics and Navigation in Medicine		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	SoSe	
Content	<ul> <li>kinematics</li> <li>calibration</li> <li>tracking systems</li> <li>navigation and image guidance</li> <li>motion compensation</li> <li>The seminar extends and complements the contents of the lecture with respect to recent research results.</li> </ul>	
Literature	Spong et al.: Robot Modeling and Control, 2005 Troccaz: Medical Robotics, 2012 Further literature will be given in the lecture.	

Course L0338: Robotics and Navigation in Medicine		
Тур	Project Seminar	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0336: Robotics and Navigation in Medicine		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M072	L: Air Conditioning			
Courses				
Title		Тур	Hrs/wk	СР
Air Conditioning (L059	4)	Lecture	3	5
Air Conditioning (L059	5)	Recitation (large)	Section 1	1
Module Responsible	Prof. Gerhard Schmitz			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid	Dynamics, Heat	Transfer	
Educational Objectives	After taking part successfully, studen	ts have reached	the following lear	ning results
Professional				
Competence	Students know the different kinds (			
Knowledge	mobile applications and how these sithe change of state of humid air and diagram. They are able to calculat conditions in rooms and can choospattern in rooms and are able to calculate simple methods. They know the prinknow the different possibilities to processes into suitable thermodynamics.	systems are con are able to draw se the minimum se suitable filter sulate the air vel- aciples to calcul produce cold a	trolled. They are the state change a airflow needed is. They know thocity in rooms with ate an air duct nend are able to	familiar with s in a h1+x,x for hygienic le basic flow the help of etwork. They draw these
Skills	Students are able to configure air applications. They are able to calcul perform simple planning tasks, regar can transfer research knowledge into work in the field of air conditioning.	ate an air duct n ding natural hea	etwork and have t sources and hea	the ability to at sinks. They
Personal Competence Social Competence	The students are able to discuss in sr	nall groups and o	develop an approa	ach.
Autonomy	Students are able to define indepo existing knowledge as well as to find			
Workload in Hours	Independent Study Time 124, Study	Fime in Lecture 5	66	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and				

scale	
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0594: Air (	Conditioning
Тур	Lecture
Hrs/wk	3
СР	
	Independent Study Time 108, Study Time in Lecture 42
	Prof. Gerhard Schmitz
Language Cycle	
	1. Overview
	1.1 Kinds of air conditioning systems
	1.2 Ventilating
	1.3 Function of an air condition system
	2. Thermodynamic processes
	2.1 Psychrometric chart
	2.2 Mixer preheater, heater
	2.3 Cooler
	2.4 Humidifier
	2.5 Air conditioning process in a Psychrometric chart
	2.6 Desiccant assisted air conditioning
	3. Calculation of heating and cooling loads
Content	3.1 Heating loads
	3.2 Cooling loads
	3.3 Calculation of inner cooling load
	3.4 Calculation of outer cooling load
	4. Ventilating systems
	4.1 Fresh air demand
	4.2 Air flow in rooms
	4.3 Calculation of duct systems

	4.4 Fans
	4.5 Filters
	5. Refrigeration systems
	5.1. compression chillers
	5.2Absorption chillers
Literature	<ul> <li>Schmitz, G.: Klimaanlagen, Skript zur Vorlesung</li> <li>VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013</li> <li>Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009</li> <li>Recknagel, H.; Sprenger, E.; Schrammek, ER.: Taschenbuch für Heizungund Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013</li> </ul>

Course L0595: Air Conditioning	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Gerhard Schmitz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M10 Technology	00: Combined Heat and Power and Combustion
Courses	
<b>Title</b> Combined Heat and Po	Typ Hrs/wk CP ower and Combustion Technology (L0216) Lecture 3 5
Combined Heat and Po	ower and Combustion Technology (L0220) Recitation Section 1 1
itesponsible	
Admission Requirements	None
Recommended Previous Knowledge	"lechnical Inermodynamics I and II"      "Heat Transfer"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	plants and are in a position to compare with each other district heating plants with back-pressure steam turbine or condensing turbine with pressure-controlled extraction tapping, CHP plants with gas turbine or with combined steam and gas turbine, or even district heating plants with an internal combustion engine. They can explain and analyse aspects of combined heat, power and cooling (CCHP) and describe the layout of the key components needed. Through this specialised knowledge they are able to evaluate the ecological significance of district CHP generation, as well as its economics.
Skills	Using thermodynamic calculations and considering the reaction kinetics the students will be able to determine interdisciplinary correlations between thermodynamic and chemical processes during combustion. This then enables quantitative analysis of the combustion of gaseous, liquid and solid fuels and determination of the quantities and concentrations of the exhaust gases. In this module the first step toward the utilisation of an energy source (combustion) to provide usable energy (electricity and heat) is taught. An understanding of both procedures enables the students to holistically consider energy utilisation. Examples taken from the praxis, such as the CHP energy supply facility of the TUHH and the district heating network of Hamburg will be used, to highlight the potential from electricity generation plants with simultaneous heat extraction.  Within the framework of the exercises the students will first learn to calculate the energetic and mass balances of combustion processes. Moreover, the students will gain a deeper understanding of the combustion processes by the calculation of reaction kinetics.
Personal Competence	

Social Competence	This animates the students to reflect on their existing knowledge and ask specific questions for improving further this knowledge level.				
Autonomy	The students assisted by the tutors will be able to perform estimating calculations. In this manner the theoretical and practical knowledge from the lecture is consolidated and the potential impact of different process arrangements and boundary conditions highlighted.				
<b>Workload in Hours</b>	Independent	Study Time	124, Study Tin	ne in Lecture	e 56
Credit points	6				
Course achievement	No 1		<b>Form</b> Written elabora	tion	Description  Am Ende jeder Vorlesung wird schriftlich eine zu auswertende Kurzfrage (5-10 min) zu der Vorlesung der Vorwoche gestellt. In den Kurzfragen werden kleine Rechenaufgaben, Skizzen oder auch kleine Freitexte zur Beantwortung gestellt.
Examination	Written exam	า			
Examination duration and scale					
Assignment for the Following Curricula	Theoretical I Compulsory	Mechanical	Engineering:	Technical C	omplementary Course: Elective

Course L0216: Com	bined Heat and Power and Combustion Technology
Тур	Lecture
Hrs/wk	3
СР	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Alfons Kather
Language	DE
Cycle	SoSe
Content	The subject area of "Combined Heat and Power" covers the following themes:  Layout, design and operation of Combined Heat and Power plants District heating plants with back-pressure steam turbine and condensing turbine with pressure-controlled extraction tapping District heating plants with gas turbine District heating plants with combined steam and gas turbine District heating plants with motor engine Combined cooling heat and power (CCHP) Layout of the key components Regulatory framework and allowable limits Economic significance and calculation of the profitability of district CHP plant whereas the subject of Combustion Technology includes:  Thermodynamic and chemical fundamentals Fuels Reaction kinetics Premixed flames Non-premixed flames Combustion of gaseous fuels Combustion of liquid fuels Combustion of solid fuels Combustion Chamber design NO <sub>x</sub> reduction
Literature	<ul> <li>Bezüglich des Themenbereichs "Kraft-Wärme-Kopplung":</li> <li>W. Piller, M. Rudolph: Kraft-Wärme-Kopplung, VWEW Verlag</li> <li>Kehlhofer, Kunze, Lehmann, Schüller: Handbuch Energie, Band 7, Technischer Verlag Resch</li> <li>W. Suttor: Praxis Kraft-Wärme-Kopplung, C.F. Müller Verlag</li> <li>K.W. Schmitz, G. Koch: Kraft-Wärme-Kopplung, VDI Verlag</li> <li>KH. Suttor, W. Suttor: Die KWK Fibel, Resch Verlag</li> <li>und für die Grundlagen der "Verbrennungstechnik":</li> <li>J. Warnatz, U. Maas, R.W. Dibble; Technische Verbrennung: physikalischchemische Grundlagen, Modellbildung, Schadstoffentstehung. Springer, Berlin [u. a.], 2001</li> </ul>

Course L0220: Combined Heat and Power and Combustion Technology		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Alfons Kather	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0512	2: Use of Solar Energy			
Courses				
Title Energy Meteorology (L	0016)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b>
Energy Meteorology (L			Section 1	1
Collector Technology (		Lecture	2	2
Solar Power Generation	· ·	Lecture	2	2
Module Responsible	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended Previous Knowledge	none			
Educational Objectives	After taking part successfully, studer	nts have reached th	e following learr	ning results
Professional Competence				
Knowledge	With the completion of this module foundations and current issues and pand evaulate these critically in consubject specific issues. In particular within a solar cell and explain the spruthermore, they can provide an thermal systems.	oroblems in the field sideration of the p they can professio pecific features of a	d of solar energy prior curriculum nally describe th application of so	and explain and current ne processes lar modules.
Skills	Students can apply the acquired systems using solar radiation. In the evaluate potential and constraints or geographical assumptions. They are consideration of technical aspect comprehensive knowledge student conditions of these systems. They radiation theory for these topics.	nis context, for exition in the solar energy system of soler to dimensions of the soler to the soler the soler the soler in the soler th	ample they can ems with respect on solar energy sumptions. Usi ne economic a	assess and to different systems ir ng module- nd ecologio
Personal Competence				
Social Competence	Students are able to discuss issues sector addressed within the module.	in the thematic fie	lds in the renew	able energy
Autonomy	Students can independently exploit about the subject area with respect the assistance of lecturers, they can and dimensioning solar energy sconcrete assess their specific learning workflow.	to emphasis fo the discrete use calcu ystems. Based or	e lectures. Furthe lation methods f this procedur	ermore, with for analysing e they car
	Independent Study Time 96, Study T	ime in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	3 hours written exam			

scale	
Assignment for the Following Curricula	Environmental Engineering: Elective Compulsory  Renewable Energies: Core qualification: Compulsory

Course L0016: Energy Meteorology			
	Typ Lecture		
Hrs/wk	1		
СР	1		
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Dr. Volker Matthias, Dr. Beate Geyer		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>Introduction: radiation source Sun, Astronomical Foundations, Fundamentals of radiation</li> <li>Structure of the atmosphere</li> <li>Properties and laws of radiation         <ul> <li>Polarization</li> <li>Radiation quantities</li> <li>Planck's radiation law</li> <li>Wien's displacement law</li> <li>Stefan-Boltzmann law</li> <li>Kirchhoff's law</li> <li>Brightness temperature</li> <li>Absorption, reflection, transmission</li> </ul> </li> <li>Radiation balance, global radiation, energy balance</li> <li>Atmospheric extinction</li> <li>Mie and Rayleigh scattering</li> <li>Radiative transfer</li> <li>Optical effects in the atmosphere</li> <li>Calculation of the sun and calculate radiation on inclined surfaces</li> </ul>		
Literature	<ul> <li>Helmut Kraus: Die Atmosphäre der Erde</li> <li>Hans Häckel: Meteorologie</li> <li>Grant W. Petty: A First Course in Atmosheric Radiation</li> <li>Martin Kaltschmitt, Wolfgang Streicher, Andreas Wiese: Renewable Energy</li> <li>Alexander Löw, Volker Matthias: Skript Optik Strahlung Fernerkundung</li> </ul>		

Course L0017: Energy Meteorology		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Beate Geyer	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0018: Coll	ector Technology
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Agis Papadopoulos
Language	DE
Cycle	SoSe
Content	<ul> <li>Introduction: Energy demand and application of solar energy.</li> <li>Heat transfer in the solar thermal energy: conduction, convection, radiation.</li> <li>Collectors: Types, structure, efficiency, dimensioning, concentrated systems.</li> <li>Energy storage: Requirements, types.</li> <li>Passive solar energy: components and systems.</li> <li>Solar thermal low temperature systems: collector variants, construction, calculation.</li> <li>Solar thermal high temperature systems: Classification of solar power plants construction.</li> <li>Solar air conditioning.</li> </ul>
Literature	<ul> <li>Vorlesungsskript.</li> <li>Kaltschmitt, Streicher und Wiese (Hrsg.). Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, 5. Auflage, Springer, 2013.</li> <li>Stieglitz und Heinzel .Thermische Solarenergie: Grundlagen, Technologie, Anwendungen. Springer, 2012.</li> <li>Von Böckh und Wetzel. Wärmeübertragung: Grundlagen und Praxis, Springer, 2011.</li> <li>Baehr und Stephan. Wärme- und Stoffübertragung. Springer, 2009.</li> <li>de Vos. Thermodynamics of solar energy conversion. Wiley-VCH, 2008.</li> <li>Mohr, Svoboda und Unger. Praxis solarthermischer Kraftwerke. Springer, 1999.</li> </ul>

Course L0015: Sola	ar Power Generation
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Alf Mews, Martin Schlecht, Roman Fritsches
Language	DE
Cycle	SoSe
Content	<ol> <li>Introduction</li> <li>Primary energy and consumption, available solar energy</li> <li>Physics of the ideal solar cell</li> <li>Light absorption PN junction characteristic values of the solar cell efficiency</li> <li>Physics of the real solar cell</li> <li>Charge carrier recombination characteristics, junction layer recombination, equivalent circuit</li> <li>Increasing the efficiency</li> <li>Methods for increasing the quantum yield, and reduction of recombination</li> <li>Straight and tandem structures</li> <li>Hetero-junction, Schottky, electrochemical, MIS and SIS-cell tandem cell</li> <li>Concentrator</li> <li>Concentrator optics and tracking systems</li> <li>Technology and properties: types of solar cells, manufacture, single crystal silicon and gallium arsenide, polycrystalline silicon, and silicon thin film cells, thin-film cells on carriers (amorphous silicon, CIS, electrochemical cells)</li> <li>Modules</li> <li>Circuits</li> </ol>
Literature	<ul> <li>A. Götzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik, Teubner Studienskripten, Stuttgart, 1995</li> <li>A. Götzberger: Sonnenenergie: Photovoltaik: Physik und Technologie der Solarzelle, Teubner Stuttgart, 1994</li> <li>HJ. Lewerenz, H. Jungblut: Photovoltaik, Springer, Berlin, Heidelberg, New York, 1995</li> <li>A. Götzberger: Photovoltaic solar energy generation, Springer, Berlin, 2005</li> <li>C. Hu, R. M. White: Solar Cells, Mc Graw Hill, New York, 1983</li> <li>HG. Wagemann: Grundlagen der photovoltaischen Energiewandlung: Solarstrahlung, Halbleitereigenschaften und Solarzellenkonzepte, Teubner, Stuttgart, 1994</li> <li>R. J. van Overstraeten, R.P. Mertens: Physics, technology and use of photovoltaics, Adam Hilger Ltd, Bristol and Boston, 1986</li> <li>B. O. Seraphin: Solar energy conversion Topics of applied physics V 01 31, Springer, Berlin, Heidelberg, New York, 1995</li> <li>P. Würfel: Physics of Solar cells, Principles and new concepts, Wiley-VCH, Weinheim 2005</li> <li>U. Rindelhardt: Photovoltaische Stromversorgung, Teubner-Reihe Umwelt, Stuttgart 2001</li> <li>V. Quaschning: Regenerative Energiesysteme, Hanser, München, 2003</li> <li>G. Schmitz: Regenerative Energien, Ringvorlesung TU Hamburg-Harburg 1994/95, Institut für Energietechnik</li> </ul>

Module M077	L: Flight Physics			
Courses				
<b>Title</b> Aerodynamics and Flig Flight Mechanics II (L0) Flight Mechanics II (L0)		Typ Lecture Lecture Recitation (large)	Hrs/wk 3 2 Section 1	<b>CP</b> 3 2
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None Basic knowledge in:			
Recommended Previous Knowledge	<ul><li>Mathematics</li><li>Mechanics</li></ul>			
Educational Objectives	After taking part successfully, students	s have reached	the following lear	ning results
Professional Competence Knowledge Skills Personal Competence				
Social Competence Autonomy				
	Independent Study Time 96, Study Tim	ne in Lecture 84	<u> </u>	
Credit points Course				
achievement	None			
Examination	Written exam			
Examination duration and scale	120 Minutes (WS) + 90 Minutes (SS)			
the Following	Aircraft Systems Engineering: Core qua International Management and Engir Elective Compulsory Product Development, Materials Development: Elective Compulsory Product Development, Materials and F Compulsory Product Development, Materials and Compulsory Theoretical Mechanical Engineering: Elective Compulsory Theoretical Mechanical Engineering: Compulsory	and Product  Production: Spe  Production: Spe  Specialisation	ion: Specialisat cialisation Produc ecialisation Mate Aircraft Systems	ion Product tion: Elective rials: Elective Engineering:

Course L0727: Aerodynamics and Flight Mechanics I		
Тур	Lecture	
Hrs/wk	3	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Prof. Frank Thielecke, Dr. Ralf Heinrich, Mike Montel	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Aerodynamics (fundamental equations of aerodynamics; compressible and incompressible flows; airfoils and wings; viscous flows)</li> <li>Flight Mechanics (Equations of motion; flight performance; control surfaces; derivatives; lateral stability and control; trim conditions; flight maneuvers)</li> </ul>	
Literature	<ul> <li>Schlichting, H.; Truckenbrodt, E.: Aerodynamik des Flugzeuges I und II</li> <li>Etkin, B.: Dynamics of Atmospheric Flight</li> <li>Sachs/Hafer: Flugmechanik</li> <li>Brockhaus: Flugregelung</li> <li>J.D. Anderson: Introduction to flight</li> </ul>	

Course L0730: Flight Mechanics II			
Тур	Lecture		
Hrs/wk	2		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Frank Thielecke, Mike Montel		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>stationary asymmetric flight</li> <li>dynamics of lateral movement</li> <li>methods of flight simulation</li> <li>eyperimental methods of flight mechanics</li> <li>model validation using system identification</li> <li>wind tunnel techniques</li> </ul>		
<ul> <li>Schlichting, H.; Truckenbrodt, E.: Aerodynamik des Flugzeuges I und II</li> <li>Etkin, B.: Dynamics of Atmospheric Flight</li> <li>Sachs/Hafer: Flugmechanik</li> <li>Brockhaus: Flugregelung</li> <li>J.D. Anderson: Introduction to flight</li> </ul>			

Course L0731: Flight Mechanics II		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Frank Thielecke, Mike Montel	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses				
Title		Тур	Hrs/wk	СР
Aircraft Systems II (L0	736)	Lecture	3	4
Aircraft Systems II (L0740)		Recitation (large)	Section 2	2
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	INONE			
Recommended Previous Knowledge	thermo dynamics			
Educational Objectives	LATTER TAKING NART SUCCESSIUM STUG	lents have reached	the following lea	rning results
Professional Competence				
Knowledge	describe the structure of primary flight control systems as well as actuation avionic, high lift systems in general along with corresponding proporties and avionic structure.			
Skills	Students are able to  • size primary flight control actuation systems  • perform a controller design process for the flight control actuators  • design high-lift kinematics			
Personal Competence				
Social Competence	Students are able to:  • Develop joint solutions in m	ixed teams		
Autonomy	Students are able to:  • derive requirements and perform appropriate yet simplified design processes for aircraft systems from complex issues and circumstances in a self-relian manner			
Workload in Hours	Independent Study Time 110, Stud	dy Time in Lecture	70	
Credit points				
Course achievement	INONE			
Examination	Written exam			
Examination duration and scale				

	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory
the Following	Product Development, Materials and Production: Specialisation Product
	Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective
	Compulsory
	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory

Course L0736: Aircraft Systems II			
Тур	Lecture		
Hrs/wk	3		
СР	4		
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	Prof. Frank Thielecke		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>Actuation (Principles of actuators; electro-mechanical actuators; mo analysis and sizing of position control systems; hydro-mechanic act systems)</li> <li>Flight Control Systems (control surfaces, hinge moments; requirements stability and controllability, actuation power; principles of reversible irreversible flight control systems; servo actuation systems)</li> <li>Landing Gear Systems (Configurations and geometries; analysis of the broads systems with respect to democrative dynamics, dynamics of the broads.</li> </ul>		
Literature	<ul> <li>Moir, Seabridge: Aircraft Systems</li> <li>Torenbek: Synthesis of Subsonic Airplane Design</li> <li>Curry: Aircraft Landing Gear Design: Principles and Practices</li> </ul>		

Course L0740: Aircraft Systems II		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Frank Thielecke	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0860: Harbour Engineering and Harbour Planning					
Courses					
Title		Тур	Hrs/wk	СР	
Harbour Engineering (I	L0809)	Lecture	2	2	
Harbour Engineering (I	L1414)	Project-/problem- based Learning	1	2	
Port Planning and Port	Construction (L0378)	Lecture	2	2	
- Itespensie	Prof. Peter Fröhle				
Admission Requirements	None				
Recommended Previous Knowledge	Basics of coastal engineering				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional					
Competence Knowledge	The students are able to define in details and to choose design approaches for the				
Skills	The students are able to select and apply appropriate approaches for the functional design of ports.				
Personal Competence					
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the functional design of ports. Additionaly, they will be able to work in team with engineers of other disciplines.				
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.				
<b>Workload in Hours</b>	Independent Study Time 110, St	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	The duration of the examination is 150 min. The examination includes tasks with				
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				

Course L0809: Harbour Engineering		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Peter Fröhle	
Language	DE	
Cycle	SoSe	
Content	<ul> <li>Fundamentals of harbor engineering         <ul> <li>Maritime transportation and waterways engineering</li> <li>Ships</li> </ul> </li> <li>Elements of harbors         <ul> <li>Harbor approaches and water-side harbor areas</li> <li>Terminal design and handling of cargo</li> <li>Quay-walls and piers</li> <li>Equipment of harbors</li> <li>Sluices and other special constructions</li> </ul> </li> <li>Connection to inland transportation / inland waterway transportation</li> <li>Protection of harbors         <ul> <li>Breakwaters and Jetties</li> <li>Wave protection of harbors</li> </ul> </li> <li>Fishery and other small harbors</li> </ul>	
Literature	Brinkmann, B.: Seehäfen, Springer 2005	

Course L1414: Harbour Engineering		
Тур	Project-/problem-based Learning	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Peter Fröhle	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0378: Port Planning and Port Construction		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Frank Feindt	
Language	DE	
Cycle	SoSe	
Content	<ul> <li>Planning and implementation of major projects</li> <li>Market analysis and traffic relations</li> <li>Planning process and plan</li> <li>Port planning in urban neighborhood</li> <li>Development of the logistics center "Port of Hamburg" in the metropolis</li> <li>Quays and waterfront structure</li> <li>Special planning Law Harbor - securing of a flexible use of the port</li> <li>Dimensioning of quays</li> <li>Flood protection structures</li> <li>Port of Hamburg - Infrastructure and development</li> <li>Preparation of areas</li> <li>Scour formation in front of shore structures</li> </ul>	
Literature	Vorlesungsumdruck, s. www.tu-harburg.de/gbt	

Courses				
<b>Title</b> Port Logistics (L0686)		<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3
Port Logistics (L1473)		Recitation (small)	Section 2	3
Module Responsible	Prof. Carlos Jahn			
Admission Requirements	INONE			
Recommended Previous Knowledge	none			
Educational Objectives		nts have reached	the following lear	ning results
Professional Competence				
competence	Th			
Knowledge	<ul> <li>After completing the module, students can</li> <li>reflect on the development of seaports (in terms of the functions of the ports and the corresponding terminals, as well as the relevant operator models) and place them in their historical context;</li> <li>explain and evaluate different types of seaport terminals and their specific characteristics (cargo, transhipment technologies, logistic functional areas);</li> <li>analyze common planning tasks (e.g. berth planning, stowage planning, yard planning) at seaport terminals and develop suitable approaches (in terms of methods and tools) to solve these planning tasks;</li> <li>identify future developments and trends regarding the planning and control of innovative seaport terminals and discuss them in a problem-oriented manner.</li> </ul>			
Skills	After completing the module, studen     recognize functional areas in     define and evaluate suitable of perform static calculations of required capacity (parking length, port access) on select of reliably estimate which book indicators in the static plane extent.	ports and seaport operating systems with regard to give spaces, equipmonted ted terminal types undary conditions	terminals; for container terr yen boundary cor ent requirements ; influence comm	nditions, e.g , quay wa non logistio
Personal Competence		nts can		
Social Competence	<ul> <li>transfer the acquired knowled</li> <li>discuss and successfully orga</li> <li>in small groups, document w</li> </ul>	nize extensive tas	k packages in sm	all groups;

Autonomy	<ul> <li>After completing the module, the students are able to</li> <li>research and select specialist literature, including standards, guidelines and journal papers, and to develop the contents independently;</li> <li>submit own parts in an extensive written elaboration in small groups in due time and to present them jointly within a fixed time frame.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	CompulsorBonus Form Description No 15 % Written elaboration		
Examination	Written exam		
Examination duration and scale			
the Following	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory nternational Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		

Course L0686: Port	t Logistics		
Тур	Lecture		
Hrs/wk	2		
СР			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Carlos Jahn		
Language	DE		
Cycle	SoSe		
Content	Port Logistics deals with the planning, control, execution and monitoring of material flows and the associated information flows in the port system and its interfaces to numerous actors inside and outside the port area.  The extraordinary role of maritime transport in international trade requires very efficient ports. These must meet numerous requirements in terms of economy, speed, safety and the environment. Against this background, the lecture Port Logistics deals with the planning, control, execution and monitoring of material flows and the associated information flows in the port system and its interfaces to numerous actors inside and outside the port area. The aim of the lecture Port Logistics is to convey an understanding of structures and processes in ports. The focus will be on different types of terminals, their characteristical layouts and the technical equipment used as well as the ongoing digitization and interaction of the players involved.  In addition, renowned guest speakers from science and practice will be regularly invited to discuss some lecture-relevant topics from alternative perspectives.  The following contents will be conveyed in the lectures:  • Instruction of structures and processes in the port  • Planning, control, implementation and monitoring of material and information flows in the port  • Fundamentals of different terminals, characteristical layouts and the technical equipment used  • Handling of current issues in port logistics		
Literature	<ul> <li>Alderton, Patrick (2013). Port Management and Operations.</li> <li>Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium.</li> <li>Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005.</li> <li>Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen.</li> <li>Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele.</li> <li>Jahn, Carlos; Saxe, Sebastian (Hg.). Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag, 2017.</li> <li>Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft</li> <li>Lun, Y.H.V. and Lai, KH. and Cheng, T.C.E. (2010). Shipping and Logistics Management.</li> <li>Woitschützke, Claus-Peter (2013). Verkehrsgeografie.</li> </ul>		

Course L1473: Port	Logistics
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
Content	The content of the exercise is the independent preparation of a scientific paper plus an accompanying presentation on a current topic of port logistics. The paper deals with current topics of port logistics. For example, the future challenges in sustainability and productivity of ports, the digital transformation of terminals and ports or the introduction of new regulations by the International Maritime Organization regarding the verified gross weight of containers. Due to the international orientation of the event, the paper is to be prepared in English.
Literature	<ul> <li>Alderton, Patrick (2013). Port Management and Operations.</li> <li>Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium.</li> <li>Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. (2005) Berlin Heidelberg: Springer-Verlag.</li> <li>Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen.</li> <li>Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele.</li> <li>Jahn, Carlos; Saxe, Sebastian (Hg.) (2017) Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag.</li> <li>Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft</li> <li>Lun, Y.H.V. and Lai, KH. and Cheng, T.C.E. (2010). Shipping and Logistics Management.</li> <li>Woitschützke, Claus-Peter (2013). Verkehrsgeografie.</li> </ul>

Module M0663	3: Marine Geotechnics			
Courses				
<b>Title</b> Marine Geotechnics (L	0548)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 2
Marine Geotechnics (L	•	Recitation (large)	Section 2	2
Steel Structures in Fou	ndation and Hydraulic Engineering (L1146)	Lecture	2	2
Module Responsible	Prof. Jürgen Grabe			
Admission Requirements	None			
Recommended Previous Knowledge	complete modules: Geotechnics I-III, Mat courses: Soil laboratory course	hematics I-III		
Educational Objectives	After taking part successfully, students h	nave reached t	the following learn	ing results
Professional Competence Knowledge Skills				
Personal Competence Social Competence Autonomy				
<b>Workload in Hours</b>	Independent Study Time 110, Study Tim	e in Lecture 7	0	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
_	Civil Engineering: Specialisation Geotech Civil Engineering: Specialisation Structur Civil Engineering: Specialisation Coastal Theoretical Mechanical Engineering: Specialisation Coastal Theoretical Mechanical Engineering: Theoretical Mechanical Engineering: Theoretical Mechanical Engineering: Security Water and Environmental Engineering: Secu	ral Engineering Engineering: ( Decialisation Markethnical Com- Epecialisation ( Eng: Specialisation)	g: Elective Compul Compulsory Maritime Technolo plementary Cour Cities: Elective Col ation Environmen	gy: Elective se: Elective mpulsory nt: Elective

Course L0548: Mar	ine Geotechnics
Тур	Lecture
Hrs/wk	1
СР	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	SoSe
Content	<ul> <li>Geotechnical investigation an description of the seabed</li> <li>Foundations of Offshore-Constructions</li> <li>cCliff erosion</li> <li>Sea dikes</li> <li>Port structures</li> <li>Flood protection structures</li> </ul>
Literature	<ul> <li>EAK (2002): Empfehlungen für Küstenschutzbauwerke</li> <li>EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke</li> <li>Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London</li> <li>Wagner P. (1990): Meerestechnik: Eine Einführung für Bauingenieure. Ernst &amp; Sohn, Berlin</li> </ul>

Course L0549: Marine Geotechnics			
Тур	Typ Recitation Section (large)		
Hrs/wk	2		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Jürgen Grabe		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1146: Steel Structures in Foundation and Hydraulic Engineering			
Тур	Lecture		
Hrs/wk	2		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Frank Feindt		
Language	DE		
Cycle			
Content	Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue		
Literature	EAU 2012, EA-Pfähle, EAB		

Courses				
Title Maritime Transport (LC	0063)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3
Maritime Transport (LC	0064)	Recitation (small)	Section 2	3
- Respensione	Prof. Carlos Jahn			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	LATTAT TAKING NATT CLICCASSTILLIV STLIGAT	nts have reached t	he following lear	ning results
Professional Competence				
Knowledge	<ul> <li>present the actors involved in their typical tasks;</li> <li>name common cargo types corresponding categories;</li> <li>explain operating forms in management in transport network weigh the advantages and distransport and apply them in posteroid present relevant factors for terminals and discuss them in estimate the potential of digit</li> </ul>	maritime shipping works; sadvantages of the ractice; the location pla a problem-oriente	and classify conting, transport e various modes anning of ports and way;	argo to th options an
Skills	<ul> <li>determine the mode of transmaritime supply chain;</li> <li>identify possible cost drivers i proposals for cost reduction;</li> <li>record, map and systematica maritime logistics chain, is solutions;</li> <li>perform risk assessments of heanalyse accidents in the fier relevance in everyday life;</li> <li>deal with current research differentiated way;</li> <li>apply different process mode activity and to work out the research of the second content of</li></ul>	n a transport chair ally analyse materidentify possible uman disruptions ld of maritime lotopics in the fiel elling methods in	n and recommential and information problems and to the supply chargistics and evalud of maritime labeled	d appropriat on flows of recommendain; uluating thei ogistics in
Personal Competence	The students are able to			
Social Competence	<ul><li>discuss and organise extensiv</li><li>document and present the ela</li></ul>		n groups;	
	The students are capable to			
	<ul> <li>research and select technical</li> </ul>	literature, includin	g standards and	guidelines;

Autonomy	<ul> <li>submit own shares in an extensive written elaboration in small groups in due time.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Tim	e 124, Study Time in Le	ecture 56	
Credit points	6			
	Compulsor <b>B</b> onus	Form	Description	
Course achievement		Subject theoretical practical work	and Teilnahme an einem Planspiel und anschließende schriftliche Ausarbeitung	
Examination	Written exam			
Examination duration and scale	120 minutes			
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

Course L0063: Mar	itime Transport
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
Content	The general tasks of maritime logistics include the planning, design, implementation and control of material and information flows in the logistics chain ship - port - hinterland. This includes technology assessment, selection, dimensioning and implementation as well as the operation of technologies.  The aim of the course is to provide students with knowledge of maritime transport and the actors involved in the maritime transport chain. Typical problem areas and tasks will be dealt with, taking into account the economic development. Thus, classical problems as well as current developments and trends in the field of maritime logistics are considered.  In the lecture, the components of the maritime logistics chain and the actors involved will be examined and risk assessments of human disturbances on the supply chain will be developed. In addition, students learn to estimate the potential of digitisation in maritime shipping, especially with regard to the monitoring of ships. Further content of the lecture is the different modes of transport in the hinterland, which students can evaluate after completion of the course regarding their advantages and disadvantages.
Literature	<ul> <li>Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005.</li> <li>Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009.</li> <li>Stopford, Martin. Maritime Economics Routledge, 2009</li> </ul>

Course L0064: Mar	itime Transport
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Carlos Jahn
Language	DE
Cycle	SoSe
Content	The exercise lesson bases on the haptic management game MARITIME. MARITIME focuses on providing knowledge about structures and processes in a maritime transport network. Furthermore, the management game systematically provides process management methodology and also promotes personal skills of the participants.
Literature	<ul> <li>Stopford, Martin. Maritime Economics Routledge, 2009</li> <li>Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005.</li> <li>Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009.</li> </ul>

Courses				
Title	No. 14 (1.0627)	Тур	Hrs/wk	СР
Marine Diesel Engine F		Lecture Recitation	Section <sub>1</sub>	4
Marine Diesel Engine F	Plants (L0638)	(large)	1	2
Module Responsible	Prof. Christopher Friedrich Wirz			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, studen	ts have reached	the following learn	ing results
Professional				
Competence				
Knowledge	<ul> <li>• explain different types four / two-stroke engines and assign types to given engines,</li> <li>• name definitions and characteristics, as well as</li> <li>• elaborate on special features of the heavy oil operation, lubrication and cooling.</li> </ul>			
	Students can  evaluate the interaction of ship, engine and propeller,  successful to the state of the state			
Skills	<ul> <li>use relationships between gas exchange, flushing, air demand, charge injection and combustion for the design of systems,</li> <li>design waste heat recovery, starting systems, controls, automation, foundation and design machinery spaces, and</li> <li>apply evaluation methods for excited motor noise and vibration.</li> </ul>			
Personal Competence				
Social Competence	The students are able to communicat in the shipbuilding and component su		in a professional e	environme
Autonomy	The widespread scope of gained situations in their future profession in			to hand
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 5	6	
Credit points	6			
Course achievement	INONE			
Examination	Oral exam			
Examination duration and scale				
Assignment for	Energy Systems: Specialisation Energ Energy Systems: Specialisation Marin Naval Architecture and Ocean Engine Theoretical Mechanical Engineering	e Engineering: C ering: Core quali	ompulsory fication: Elective C	

Curricula	Compulsory	•					
	Theoretical	Mechanical	Engineering:	Specialisation	Maritime	Technology:	Elective
	Compulsory	•					

Course L0637: Marine Diesel Engine Plants			
Тур	Lecture		
Hrs/wk	3		
СР	4		
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	Prof. Christopher Friedrich Wirz		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>Historischer Überblick</li> <li>Bauarten von Vier- und Zweitaktmotoren als Schiffsmotoren</li> <li>Vergleichsprozesse, Definitionen, Kenndaten</li> <li>Zusammenwirken von Schiff, Motor und Propeller</li> <li>Ausgeführte Schiffsdieselmotoren</li> <li>Gaswechsel, Spülverfahren, Luftbedarf</li> <li>Aufladung von Schiffsdieselmotoren</li> <li>Einspritzung und Verbrennung</li> <li>Schwerölbetrieb</li> <li>Schmierung</li> <li>Kühlung</li> <li>Wärmebilanz</li> <li>Abwärmenutzung</li> <li>Anlassen und Umsteuern</li> <li>Regelung, Automatisierung, Überwachung</li> <li>Motorerregte Geräusche und Schwingungen</li> <li>Fundamentierung</li> <li>Gestaltung von Maschinenräumen</li> </ul>		
Literature	<ul> <li>D. Woodyard: Pounder's Marine Diesel Engines</li> <li>H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik</li> <li>K. Kuiken: Diesel Engines</li> <li>Mollenhauer, Tschöke: Handbuch Dieselmotoren</li> <li>Projektierungsunterlagen der Motorenhersteller</li> </ul>		

Course L0638: Marine Diesel Engine Plants			
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Christopher Friedrich Wirz		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0692	2: Approximatio	n and Stabil	ity		
Courses					
Title Approximation and Stability (L0487) Approximation and Stability (L0488)			Typ Lecture Recitation (small)	Hrs/wk 3 Section 1	<b>CP</b> 4 2
Module Responsible	TPIOLIVIAIRO LIDODEI		(2000)		
Admission Requirements	None				
Recommended Previous Knowledge	eigenvalues, sin	igular values	•	·	s problems
Educational Objectives	I VITAL LANDO DALL CITAL	essfully, students h	ave reached t	he following learr	ning results
Professional Competence					
Knowledge	<ul> <li>sketch and interrelate basic concepts of functional analysis (Hilbert space, operators),</li> <li>name and understand concrete approximation methods,</li> <li>name and explain basic stability theorems,</li> <li>discuss spectral quantities, conditions numbers and methods of regularisation</li> </ul>				
Skills	<ul> <li>annly annrovim:</li> </ul>	heorems, al quantities,	l analysis,		
Personal Competence				s and to present	their results
Autonomy	<ul> <li>Students are ca their own. They help in solving t</li> <li>Students have of</li> </ul>	pable of checking can specify open hem.	their understa questions pre nt persistence	to be able to wo	where to ge
Workload in Hours	Independent Study Tin	ne 124, Study Tim	e in Lecture 5	6	
Credit points	·				
Course achievement	CompulsorBonus Yes None	<b>Form</b> Presentation	D	escription	
Examination	Oral exam				
Examination duration and scale	20 min				
	Electrical Engineering	: Specialisation (	Control and	Power Systems	Engineering

	Elective Compulsory Mathematical Modelling in Engineering: Theory, Numerics, Applications: Specialisation I. Numerics (TUHH): Elective Compulsory					
the Following	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					
Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective					
	Compulsory					
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory					

Course L0487: App	roximation and Stability
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	SoSe
Content	This course is about solving the following basic problems of Linear Algebra,  • systems of linear equations, • least squares problems, • eigenvalue problems  but now in function spaces (i.e. vector spaces of infinite dimension) by a stable approximation of the problem in a space of finite dimension.  Contents:  • crash course on Hilbert spaces: metric, norm, scalar product, completeness • crash course on operators: boundedness, norm, compactness, projections • uniform vs. strong convergence, approximation methods • applicability and stability of approximation methods, Polski's theorem • Galerkin methods, collocation, spline interpolation, truncation • convolution and Toeplitz operators • crash course on C*-algebras • convergence of condition numbers • convergence of spectral quantities: spectrum, eigen values, singular values, pseudospectra • regularisation methods (truncated SVD, Tichonov)
Literature	<ul> <li>R. Hagen, S. Roch, B. Silbermann: C*-Algebras in Numerical Analysis</li> <li>H. W. Alt: Lineare Funktionalanalysis</li> <li>M. Lindner: Infinite matrices and their finite sections</li> </ul>

Course L0488: Approximation and Stability			
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Marko Lindner		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0653	3: High-Performance Comp	uting		
Courses				
Title		Тур	Hrs/wk	СР
Fundamentals of High-	Performance Computing (L0242)	Lecture	2	3
Fundamentals of High-	Performance Computing (L1416)	Project-/problem- based Learning	2	3
- Respension	Prof. Thomas Rung			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in usage of mo	dern IT environment		
Educational Objectives	After taking part successfully, students	have reached the foll	owing learn	ing results
Professional Competence				
	Students are able to outline the fundamentals of numerical algorithms for high-performance computers by reference to modern hardware examples. Students can explain the relation between hard- and software aspects for the design of algorithms.			
Skills	Student can perform a critical assessimulation approaches.	esment of the comp	utational e	efficiency of
Personal				
Competence		algorithms in a toam		
i i	Students are able to develop and code algorithms in a team.			
Autonomy				
	Independent Study Time 124, Study Ti	me in Lecture 56		
Credit points Course achievement	None			
Examination	Written exam			
Examination duration and scale				
Assignment for the Following	Naval Architecture and Ocean Engineer Theoretical Mechanical Engineering: Compulsory Theoretical Mechanical Engineering: S Compulsory	Technical Compleme	ntary Cour	se: Elective

Course L0242: Fundamentals of High-Performance Computing			
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Thomas Rung		
Language	DE/EN		
Cycle	SoSe		
Content	Fundamentals of modern hardware architectur, critical hard- & software aspects for efficient processing of exemplary algorithms, concepts for shared- and distributed-memory systems, implementations for accelerator hardware (GPGPUs)		
Literature	1) Vortragsmaterialien und Problemanleitungen  2) G. Hager G. Wellein: Introduction to High Performance Computing for Scientists and Engineers CRC Computational Science Series, 2010		

Course L1416: Fundamentals of High-Performance Computing		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Thomas Rung	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M055	L: Pattern Recognition a	and Data Comp	ression	
Courses				
Title		Тур	Hrs/wk	СР
Pattern Recognition an	d Data Compression (L0128)	Lecture	4	6
Module Responsible	Prof. Rolf-Rainer Grigat			
Admission Requirements	None			
	Linear algebra (including PCA, unitarithmetics	tary transforms), stoc	hastics and stati	stics, binary
Educational Objectives	After taking part successfully, stud	lents have reached th	e following learn	ing results
Professional Competence				
	Students can name the basic conc	epts of pattern recogi	nition and data c	ompression.
Knowledge	Students are able to discuss logic the course and to explain them by		een the concepts	covered in
Skills	Students can apply statistical recognition and to prediction in methodical basis they can a classifications and describe data able to use highly sophisticated Students are capable of assessing decision-making areas.	data compression. ( nalyze characteristic compression and vio I methods and proc	On a sound theo to value assign deo signal codin esses of the su	oretical and ments and g. They are ubject area.
Personal Competence				
Social Competence	k.A.			
Autonomy	Students are capable of identifyi scientifically, using the methods the		dently and of s	olving them
Workload in Hours	Independent Study Time 124, Stud	dy Time in Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 Minutes, Content of Lecture and	d materials in StudIP		
	Computer Science: Specialisation Electrical Engineering: Specialisa Elective Compulsory Information and Communication Systems, Focus Software and Sign Information and Communication Species Signal Processing: Elective Communication Species	stion Information and systems: Specialisational al Processing: Elective Systems: Specialisation	d Communication  n Secure and Dee Compulsory	n Systems: pendable IT

Assignment for	International	Management	and	Engineering:	Specialisation	II.	Information
the Following	Technology: El	ective Compuls	ory				
Curricula	International M	lanagement an	d Eng	ineering: Specia	alisation II. Elect	rical	Engineering:
	Elective Comp	•					
	Mechatronics:	Specialisation I	ntellig	ent Systems ar	nd Robotics: Elec	tive	Compulsory
	Mechatronics:	Technical Comp	pleme	ntary Course: E	lective Compuls	ory	
	Theoretical M	echanical Engi	neerin	g: Technical C	Complementary	Cour	se: Elective
	Compulsory						
	Theoretical Me	echanical Engin	eering	: Specialisation	Robotics and C	ompi	ıter Science:
	Elective Comp	ulsory					

Course L0128: Pattern Recognition and Data Compression				
Тур	Lecture			
Hrs/wk	4			
СР	6			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
Lecturer	Prof. Rolf-Rainer Grigat			
Language	EN			
Cycle	SoSe			
	Structure of a pattern recognition system, statistical decision theory, classification based on statistical models, polynomial regression, dimension reduction, multilayer perceptron regression, radial basis functions, support vector machines, unsupervised learning and clustering, algorithm-independent machine learning, mixture models and EM, adaptive basis function models and boosting, Markov random fields  Information, entropy, redundancy, mutual information, Markov processes, basic coding schemes (code length, run length coding, prefix-free codes), entropy coding (Huffman, arithmetic coding), dictionary coding (LZ77/Deflate/LZMA2, LZ78/LZW), prediction, DPCM, CALIC, quantization (scalar and vector quantization), transform coding, prediction, decorrelation (DPCM, DCT, hybrid DCT, JPEG, JPEG-LS), motion estimation, subband coding, wavelets, HEVC (H.265,MPEG-H)			
Literature	Schürmann: Pattern Classification, Wiley 1996 Murphy, Machine Learning, MIT Press, 2012 Barber, Bayesian Reasoning and Machine Learning, Cambridge, 2012 Duda, Hart, Stork: Pattern Classification, Wiley, 2001 Bishop: Pattern Recognition and Machine Learning, Springer 2006 Salomon, Data Compression, the Complete Reference, Springer, 2000 Sayood, Introduction to Data Compression, Morgan Kaufmann, 2006 Ohm, Multimedia Communication Technology, Springer, 2004 Solari, Digital video and audio compression, McGraw-Hill, 1997 Tekalp, Digital Video Processing, Prentice Hall, 1995			

Module M0627	7: Machine Learning	and Data Mir	ing		
Courses					
<b>Title</b> Machine Learning and	Data Mining (L0340)	<b>Typ</b> Lecture	6 11	Hrs/wk 2	<b>CP</b> 4
Machine Learning and	Data Mining (L0510)	Recitation (small)	on Section	12	2
Module Responsible	NN				
Admission Requirements	None				
Recommended Previous Knowledge	Calculus     Stochastics				
Educational Objectives	After taking part successfully,	students have read	hed the follo	wing learn	ing results
Professional Competence					
Knowledge	Students can explain the di learning approaches, and they each of the two basic approaches of incrementally incoming data suitable representation form parameters, or structures used with different algorithms. Structures. They depict how the by ensemble learning, and the learning theory. Algorithms for students.	r can enumerate bathes, either on the late. For dealing with lates and theyed in these formalised are also a late performance of ley can summarize	sic machine basis of static uncertainty, explain ho sms can be ble to sketc learned class how this infl	learning to c data, or students on ow axiom learned a h differen ifiers can l uences co	echnique for on the basis can describe s, features, utomatically it clustering be improved imputational
Skills	Student derive decision trees static data tables and are able. They present and apply the apply the BME, MAP, ML, and networks and compare the di Gaussian mixture learning. Th support vector machines, and properties. Students can desc components of those technit techniques, e.g., k-means cludistinguish various ensemble of those techniques.	e to name and exp basic idea of first I EM algorithms fo fferent algorithms. ey can contrast kN I name their basic ribe basic clusterin ques. Students co stering and neares	lain basic op -order induct r learning pa They also k IN classifiers, application a g techniques ompare relat t neighbor cl	timization ive leanir rameters now how neural ne areas and and expla ed machi assificatio	techniques.  ng. Students of Bayesian to carry out etworks, and algorithmic ain the basic ne learning on. They can
Personal Competence Social Competence Autonomy					
	Independent Study Time 124,	Study Time in Lect	ure 56		
Credit points Course achievement					
-	Written exam				
Examination					

duration and scale	
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0340: Mac	hine Learning and Data Mining
Тур	Lecture
Hrs/wk	2
СР	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	SoSe
Content	<ul> <li>Decision trees</li> <li>First-order inductive learning</li> <li>Incremental learning: Version spaces</li> <li>Uncertainty</li> <li>Bayesian networks</li> <li>Learning parameters of Bayesian networks BME, MAP, ML, EM algorithm</li> <li>Learning structures of Bayesian networks</li> <li>Gaussian Mixture Models</li> <li>kNN classifier, neural network classifier, support vector machine (SVM) classifier</li> <li>Clustering Distance measures, k-means clustering, nearest neighbor clustering</li> <li>Kernel Density Estimation</li> <li>Ensemble Learning</li> <li>Reinforcement Learning</li> <li>Computational Learning Theory</li> </ul>
Literature	<ol> <li>Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russel, Peter Norvig, Prentice Hall, 2010, Chapters 13, 14, 18-21</li> <li>Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press 2012</li> </ol>

Course L0510: Machine Learning and Data Mining		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Rainer Marrone	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0606	5: Numerical Algorithm	s in Structural	Mechanics		
Courses					
<b>Title</b> Numerical Algorithms i	in Structural Mechanics (L0284) in Structural Mechanics (L0285)	<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3	
Module Responsible	Prof. Alexander Düster	(Smail)			
Admission Requirements					
Recommended Previous Knowledge	Knowlodge of partial differential	equations is recomme	nded.		
Educational Objectives	After taking part successfully, st	udents have reached t	he following learr	ning results	
Professional Competence					
Knowledge	Students are able to + give an overview of the standard algorithms that are used in finite element programs. + explain the structure and algorithm of finite element programs. + specify problems of numerical algorithms, to identify them in a given situation and to explain their mathematical and computer science background.				
Skills	Students are able to + construct algorithms for given numerical methods. + select for a given problem of structural mechanics a suitable algorithm. + apply numerical algorithms to solve problems of structural mechanics. + implement algorithms in a high-level programming languate (here C++). + critically judge and verfiy numerical algorithms.				
Personal Competence					
Social Competence	Students are able to + solve problems in heterogen results.	eous groups and to	document the co	orresponding	
Autonomy	Students are able to + acquire independently knowledge to solve complex problems.				
Workload in Hours	Independent Study Time 124, St	udy Time in Lecture 56	5		
Credit points					
Course achievement	None				
Examination					
Examination duration and scale					
Assignment for the Following	Materials Science: Specialisation Modeling: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory				

Course L0284: Numerical Algorithms in Structural Mechanics			
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Alexander Düster		
Language	DE		
Cycle	SoSe		
Content	<ol> <li>Motivation</li> <li>Basics of C++</li> <li>Numerical integration</li> <li>Solution of nonlinear problems</li> <li>Solution of linear equation systems</li> <li>Verification of numerical algorithms</li> <li>Selected algorithms and data structures of a finite element code</li> </ol>		
Literature	[1] D. Yang, C++ and object-oriented numeric computing, Springer, 2001. [2] KJ. Bathe, Finite-Elemente-Methoden, Springer, 2002.		

Course L0285: Numerical Algorithms in Structural Mechanics		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Düster	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M071	1: Numerical Mathematics II
Courses	
<b>Title</b> Numerical Mathematic	Recitation Section
Module Responsible	Prof Sahina La Borna
Admission Requirements	
Recommended Previous Knowledge	Numerical Mathematics I     MATI AB knowledge
Educational Objectives	
Professional Competence Knowledge	<ul> <li>Students are able to</li> <li>name advanced numerical methods for interpolation, integration, linear leas squares problems, eigenvalue problems, nonlinear root finding problems and explain their core ideas,</li> <li>repeat convergence statements for the numerical methods,</li> <li>sketch convergence proofs,</li> <li>explain practical aspects of numerical methods concerning runtime and</li> </ul>
Skills	<ul> <li>implement, apply and compare advanced numerical methods in MATLAB,</li> <li>justify the convergence behaviour of numerical methods with respect to the problem and solution algorithm and to transfer it to related problems,</li> </ul>
Personal Competence	Students are able to
Social Competence	<ul> <li>work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms.</li> </ul>
	Students are capable
Autonomy	<ul> <li>to assess whether the supporting theoretical and practical excercises are better solved individually or in a team,</li> <li>to assess their individual progess and, if necessary, to ask questions and</li> </ul>

	seek help.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	25 min
_	Computer Science: Specialisation III. Mathematics: Elective Compulsory Computational Science and Engineering: Specialisation III. Mathematics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L0568: Numerical Mathematics II	
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	SoSe
Content	<ol> <li>Error and stability: Notions and estimates</li> <li>Interpolation: Rational and trigonometric interpolation</li> <li>Quadrature: Gaussian quadrature, orthogonal polynomials</li> <li>Linear systems: Perturbation theory of decompositions, structured matrices</li> <li>Eigenvalue problems: LR-, QD-, QR-Algorithmus</li> <li>Krylov space methods: Arnoldi-, Lanczos methods</li> </ol>
Literature	<ul> <li>Stoer/Bulirsch: Numerische Mathematik 1, Springer</li> <li>Dahmen, Reusken: Numerik für Ingenieure und Naturwissenschaftler, Springer</li> </ul>

Course L0569: Numerical Mathematics II	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1143	3: Applied Design Meth	odology in Mecha	atronics	
Courses				
<b>Title</b> Applied Design Method	dology in Mechatronics (L1523) dology in Mechatronics (L1524)	<b>Typ</b> Lecture Project-/problem-	Hrs/wk 2 3	<b>CP</b> 2
Module	Prof. Thorsten Kern	based Learning		
Admission				
Requirements Recommended Previous Knowledge	Basics of mechanical design, electrical design or computer-sciences			
Educational Objectives	After taking part successfully, stu	dents have reached the f	ollowing learn	ing results
Professional Competence	Science-based working on inter-		ign consideri	ng targete
	application of specific product design techniques  Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various product design techniques following theoretical aspects.			
Personal Competence				
Social Competence	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application of common, creative methodologies.			
Autonomy	the target and topic of the design			
	Independent Study Time 110, Study Time in Lecture 70			
Credit points Course achievement	None			
	Subject theoretical and practical v	vork		
Examination	30 min Presentation for a group d			
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective			

Compulsory

Course L1523: App	lied Design Methodology in Mechatronics
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	
Cycle	SoSe
Content	<ul> <li>Systematic analysis and planning of the design process for products combining a multitude of disciplines</li> <li>Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation)</li> <li>Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics)</li> <li>Several design-supporting methods and tools (functional strcutures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing,)</li> <li>Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making</li> <li>Value-analysis</li> <li>Derivation of architectures and architectural management</li> <li>Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&amp;D departments, idea-identification, responsibilities and communication)</li> <li>Project-execution methods (Scrum, Kanbaan,)</li> <li>Presentation-skills</li> <li>Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces)</li> <li>Evaluation of selected methods at practical examples in small teams</li> </ul>
Literature	<ul> <li>Definition folgt</li> <li>Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage Springer Verlag, Berlin 2007</li> <li>VDI-Richtlinien: 2206; 2221ff</li> </ul>

Course L1524: Applied Design Methodology in Mechatronics	
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

	05: Technical Acoustics ycho Acoustics )	I (Acous	tic Waves,	Noise
Courses				
Title		Тур	Hrs/wk	СР
Technical Acoustics I ( Acoustics ) (L0516)	Acoustic Waves, Noise Protection, Psycho	Lecture	2	3
Technical Acoustics I ( Acoustics ) (L0518)	Acoustic Waves, Noise Protection, Psycho	Recitation (large)	Section 2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements				
Recommended Previous Knowledge	Kinematics, Dynamics)			
	After taking part successfully students	•		ing results
Professional Competence				
Knowledge	The students possess an in-depth knowledge in acoustics regarding acoustic waves, noise protection, and psycho acoustics and are able to give an overview of the corresponding theoretical and methodical basis.			
Skills	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding methodologies and measurement procedures treated within the module.			
Personal Competence				
Social Competence	Students can work in small groups on s	specific problems	s to arrive at joint	solutions.
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible conflicting issues and limitations can be identified and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture 56	5	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Compulsory	eation Cabin Systemering: Special esign: Elective Conduction:  Engineering Scientist Company C	tems: Elective Colisation II. Aviation Compulsory Compulsory Core qualification ence: Elective Colonementary Court	on Systems: on: Elective mpulsory se: Elective

Course L0516: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics )		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Otto von Estorff	
Language	EN	
Cycle	SoSe	
Content	<ul> <li>Introduction and Motivation</li> <li>Acoustic quantities</li> <li>Acoustic waves</li> <li>Sound sources, sound radiation</li> <li>Sound engergy and intensity</li> <li>Sound propagation</li> <li>Signal processing</li> <li>Psycho acoustics</li> <li>Noise</li> <li>Measurements in acoustics</li> </ul>	
Literature	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg	

Course L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Otto von Estorff	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1170	D: Phenomena and Methods	in Materials S	cience	
Courses				
	for the Characterization of Materials (L1580) ansformations (L1579)	Typ Lecture Lecture	Hrs/wk 2 2	<b>CP</b> 3 3
Module Responsible	Prof. Jörg Weißmüller			
Admission Requirements	none			
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.q	g. Werkstoffwissensch	naft I/II	
Educational Objectives	After taking part successfully, students h	ave reached the follo	wing learn	ing results
Professional Competence				
Knowledge	The students will be able to explain the patheir applications in technology, in semiconductor, modern composite mater	particular metallic,	ceramic,	polymeric,
Skills	The students will be able to select technical needs and, if necessary, to desprinciples from the micro- to the materials of materials combinations depending on the	ign new materials con acroscale. The studen e, which enables the	nsidering a nts will a m to sele	architectural Iso gain an
Personal Competence	The students are able to present solu	tions to specialists a	and to de	velop ideas
Social Competence	further.  The students are able to			
Autonomy	<ul><li>assess their own strengths and we</li><li>gather new necessary expertise by</li></ul>			
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56		
Credit points				
Course achievement	None			
	Written exam			
Examination duration and scale	90 min			
the Following	Development: Elective Compulsory Product Development, Materials and Pro Compulsory	mpulsory nd Production: Sp duction: Specialisatio d Production: Spe	pecialisation on Producti	on Production: Elective  Materials:

Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L1580: Experimental Methods for the Characterization of Materials		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Patrick Huber	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography)</li> <li>Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements)</li> <li>Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)</li> </ul>	
Literature	William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011). William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).	

Course L1579: Phase equilibria and transformations				
Тур	Lecture			
Hrs/wk	2			
СР	3			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Jörg Weißmüller			
Language	DE			
Cycle	WiSe			
Content	Fundamentals of statistical physics, formal structure of phenomenological thermodynamics, simple atomistic models and free-energy functions of solid solutions and compounds. Corrections due to nonlocal interaction (elasticity, gradient terms). Phase equilibria and alloy phase diagrams as consequence thereof. Simple atomistic considerations for interaction energies in metallic solid solutions. Diffusion in real systems. Kinetics of phase transformations for real-life boundary conditions. Partitioning, stability and morphology at solidification fronts. Order of phase transformations; glass transition. Phase transitions in nano- and microscale systems.			
Literature	D.A. Porter, K.E. Easterling, "Phase transformations in metals and alloys", New York, CRC Press, Taylor & Francis, 2009, 3. Auflage  Peter Haasen, "Physikalische Metallkunde", Springer 1994  Herbert B. Callen, "Thermodynamics and an introduction to thermostatistics", New York, NY: Wiley, 1985, 2. Auflage.  Robert W. Cahn und Peter Haasen, "Physical Metallurgy", Elsevier 1996  H. Ibach, "Physics of Surfaces and Interfaces" 2006, Berlin: Springer.			

Module M1152: Modeling Across The Scales							
Courses							
Title  Modeling Across The Scales (L1537)  Modeling Across The Scales - Excercise (L1538)		<b>Typ</b> Lecture Recitation	Hrs/w 2 Section <sub>2</sub>	<b>/k CP</b> 3			
_		(small)					
Admission Requirements							
Recommended Previous Knowledge	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (forces and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy).						
Educational Objectives	After taking part successfully, studer	its have reached	the following le	arning results			
Professional Competence							
Knowledge	and can name the appropriate kind o	of modeling conce	pt suited for its	description.			
Skills	The students are able to predict first based on the material's microstructudamage behavior of materials baparticular, they are able to apply the science and evaluate and implement	ire. They are able ised on their m eir knowledge to	e to correlate a nicromechanica different proble	nd describe the al behavior. In ems of material			
Personal							
Competence Social Competence	The students are able to develop so develop ideas further.	olutions, to prese	ent them to sp	ecialists and to			
Autonomy	The students are able to assess their own strengths and weaknesses. They car independently and on their own identify and solve problems in the area of scale bridging modeling and acquire the knowledge required to this end.						
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 5	6				
Credit points	6						
Course achievement	None						
Examination							
Examination duration and scale							
the Following	Materials Science: Specialisation Mod Theoretical Mechanical Engineering Compulsory Theoretical Mechanical Engineering Compulsory	ı: Technical Com	plementary Co				

Course L1537: Modeling Across The Scales					
Тур	Lecture				
Hrs/wk	2				
СР	3				
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28				
Lecturer	Prof. Christian Cyron				
Language	DE				
Cycle	SoSe				
Content	<ul> <li>modeling of deformation mechanisms in materials at different scales (e.g., molecular dynamics, crystal plasticity, phenomenological models,)</li> <li>relationship between microstructure and macroscopic mechanical material behavior</li> <li>Eshelby problem</li> <li>effective material properties, concept of RVE</li> <li>homogenisation methods, coupling of scales (micro-meso-macro)</li> <li>micromechanical concepts for the description of damage and failure behavior</li> </ul>				
Literature	<ul> <li>D. Gross, T. Seelig, Bruchmechanik: Mit einer Einführung in die Mikromechanik, Springer</li> <li>T. Zohdi, P. Wriggers: An Introduction to Computational Micromechanics</li> <li>D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch</li> <li>G. Gottstein., Physical Foundations of Materials Science, Springer</li> </ul>				

Course L1538: Modeling Across The Scales - Excercise						
Тур	Recitation Section (small)					
Hrs/wk	2					
СР	3					
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28					
Lecturer	Prof. Christian Cyron					
Language	DE					
Cycle	SoSe					
Content	<ul> <li>modeling of deformation mechanisms in materials at different scales (e.g., molecular dynamics, crystal plasticity, phenomenological models,)</li> <li>relationship between microstructure and macroscopic mechanical material behavior</li> <li>Eshelby problem</li> <li>effective material properties, concept of RVE</li> <li>homogenisation methods, coupling of scales (micro-meso-macro)</li> <li>micromechanical concepts for the description of damage and failure behavior</li> </ul>					
Literature	<ul> <li>D. Gross, T. Seelig, Bruchmechanik: Mit einer Einführung in die Mikromechanik, Springer</li> <li>T. Zohdi, P. Wriggers: An Introduction to Computational Micromechanics</li> <li>D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch</li> <li>G. Gottstein., Physical Foundations of Materials Science, Springer</li> </ul>					

Module M0807	7: Boundary Elen	nent Metho	ds			
Courses						
Title Boundary Element Met			<b>Typ</b> Lecture Recitation	Hrs/wk 2 Section 2	<b>CP</b> 3	
Boundary Element Met	hods (L0524)		(large)	2	3	
Module Responsible	Prof. Otto von Estorff					
Admission Requirements	None					
Recommended Previous Knowledge	Kinematics, Dynamics)  Mathematics L. II. III (in particular differential equations)					
Educational Objectives	After taking part successfully, students have reached the following learning results					
Professional Competence						
Knowledge	The students possess boundary element met methodical basis of the	hod and are able				
Skills	The students are capal boundary elements, ass resulting system of equ	sembling the corre				
Personal Competence	Students can work in sr	mall groups on spo	acific problems	to arrive at joint	solutions	
Social Competence	Students can work in si	nan groups on spe	ecinc problems	to arrive at joint	SOIULIONS.	
Autonomy	The students are able and develop own boun results are critically scre	idary element rou				
Workload in Hours	Independent Study Time	e 124, Study Time	e in Lecture 56			
Credit points	<u>.                                      </u>					
Course achievement	CompulsorBonus No 20 %	<b>Form</b> Midterm	De	escription		
Examination	Written exam					
Examination duration and scale						
	Civil Engineering: Speci Civil Engineering: Speci Civil Engineering: Speci Energy Systems: Core c	alisation Geotech alisation Coastal	nical Engineer Engineering: E	ng: Elective Com ective Compulsor	pulsory	

Assignment fo the Following Curricula	Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective		
Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Ele Compulsory			

Course L0523: Boundary Element Methods				
Тур	Lecture			
Hrs/wk	2			
СР	3			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Lecturer Prof. Otto von Estorff			
Language	EN			
Cycle	SoSe			
Content	- Boundary value problems - Integral equations - Fundamental Solutions - Element formulations - Numerical integration - Solving systems of equations (statics, dynamics) - Special BEM formulations - Coupling of FEM and BEM - Hands-on Sessions (programming of BE routines) - Applications			
Literature	Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin			

Course L0524: Boundary Element Methods		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Otto von Estorff	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0604	l: High-Order FE	■M						
Courses								
<b>Title</b> High-Order FEM (L0280	0)		<b>Typ</b> Lecture Recitation	Hrs/wk 3 Section 1	<b>CP</b> 4			
High-Order FEM (L028)	1)	(large)						
Module Responsible	Prof. Alexander Düster							
Admission Requirements	None	one						
Recommended Previous Knowledge	Knowledge of partial di	Knowledge of partial differential equations is recommended.						
Educational Objectives	After taking part succe	ssfully, students h	nave reached	the following learr	ing results			
Professional Competence								
Knowledge	Students are able to + give an overview of the different (h, p, hp) finite element procedures. + explain high-order finite element procedures. + specify problems of finite element procedures, to identify them in a given situation and to explain their mathematical and mechanical background.							
Skills	Students are able to + apply high-order finite elements to problems of structural mechanics. + select for a given problem of structural mechanics a suitable finite element procedure. + critically judge results of high-order finite elements. + transfer their knowledge of high-order finite elements to new problems.							
Personal Competence								
Social Competence	Students are able to + solve problems in results.	+ solve problems in heterogeneous groups and to document the corresponding						
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks.							
<b>Workload in Hours</b>	Independent Study Tim	ne 124, Study Tim	e in Lecture 5	6				
Credit points								
Course achievement	No 10 %	<b>Form</b> Presentation		<b>Description</b> orschendes Lerner	า			
Examination	Written exam							
Examination duration and scale								
	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory							

I	Curricula	Product	Development,	Materials	and	Production:	Core	qualification:	Elective
l		Compuls							
		Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory					pulsory		
		Theoreti	cal Mechanical	Engineerin	g: Te	chnical Com	pleme	ntary Course:	Elective
		Compuls	ory						
		Theoreti	cal Mechanical E	Engineering	: Core	e qualification	: Electi	ive Compulsory	,

Course L0280: High	n-Order FEM
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	<ol> <li>Introduction</li> <li>Motivation</li> <li>Hierarchic shape functions</li> <li>Mapping functions</li> <li>Computation of element matrices, assembly, constraint enforcement and solution</li> <li>Convergence characteristics</li> <li>Mechanical models and finite elements for thin-walled structures</li> <li>Computation of thin-walled structures</li> <li>Error estimation and hp-adaptivity</li> <li>High-order fictitious domain methods</li> </ol>
Literature	[1] Alexander Düster, High-Order FEM, Lecture Notes, Technische Universität Hamburg-Harburg, 164 pages, 2014 [2] Barna Szabo, Ivo Babuska, Introduction to Finite Element Analysis – Formulation, Verification and Validation, John Wiley & Sons, 2011

Course L0281: High-Order FEM		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Alexander Düster	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M083!	5։ Hւ	umano	oid Rol	botics	5				
Courses									
Title Humanoid Robotics (LO	0663)					<b>Typ</b> Seminar		Hrs/wk 2	<b>CP</b> 2
Module Responsible	Patric	k Göttsc	h						
Admission Requirements	INODE								
Recommended Previous Knowledge	•		ction to c theory a						
Educational Objectives	LATEAL	taking pa	art succe	ssfully,	students	nave reached	the follo	wing learn	ing results
Professional Competence									
Knowledge			ts learn to		ımanoid ro basic con	obots. trol concepts	for differ	rent tasks i	in humanoid
Skills	•	<ul> <li>Students acquire knowledge about selected aspects of humanoid robotics, based on specified literature</li> <li>Students generalize developed results and present them to the participants</li> <li>Students practice to prepare and give a presentation</li> </ul>							
Personal Competence									
Social Competence		present They a	them	to prov	vide appr	ing solutions opriate feedb			
Autonomy		present Student	ation for ts familia low prese	specific	tasks and mselves v	and drawb d select the b with a scientif r students, su	est solut ic field, a	ion are able of	introduce it
Workload in Hours	-	endent S	Study Tim	ne 32, S	tudy Time	e in Lecture 28	3		
Credit points	4								
Course achievement	<u> </u>								
Examination Examination duration and scale	30 mi								
	Mecha Mecha Biome Electi Biome	atronics: edical En ve Comp	Specialis gineering ulsory	sation Sy g: Speci	ystem De alisation <i>i</i>	Systems and I sign: Elective Artificial Orga n Implants a	Compuls ns and R	sory Legenerativ	ve Medicine:

Assignment for	Biomedical Engineering: Specialisation Medical Technology and Control Theory:
the Following	Elective Compulsory
Curricula	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory

Course L0663: Hun	Course L0663: Humanoid Robotics				
Тур	Seminar				
Hrs/wk	2				
СР	2				
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28				
Lecturer	Patrick Göttsch				
Language	DE				
Cycle	SoSe				
Content	<ul> <li>Grundlagen der Regelungstechnik</li> <li>Control systems theory and design</li> </ul>				
Literature	- B. Siciliano, O. Khatib. "Handbook of Robotics. Part A: Robotics Foundations", Springer (2008).				

Module M083	8: Linear and Nonline	ar System Identifi	kation		
Courses					
<b>Title</b> Linear and Nonlinear S	System Identification (L0660)	<b>Typ</b> Lecture	Hrs/wk CP 2 3		
Module Responsible	Prof. Herbert Werner				
Admission Requirements	INIONA				
Recommended Previous Knowledge	<ul> <li>Discrete-time systems</li> </ul>	value decomposition			
Educational Objectives	I ATTOR TAKING NART CHACCETHING	students have reached the	following learning results		
Professional Competence					
Knowledge	<ul> <li>Students can explain the general framework of the prediction error method and its application to a variety of linear and nonlinear model structures</li> <li>They can explain how multilayer perceptron networks are used to model nonlinear dynamics</li> <li>They can explain how an approximate predictive control scheme can be based on neural network models</li> <li>They can explain the idea of subspace identification and its relation to Kalmar realisation theory</li> </ul>				
Skills	<ul> <li>Students are capable of applying the predicition error method to the experimental identification of linear and nonlinear models for dynamic systems</li> <li>They are capable of implementing a nonlinear predictive control scheme based on a neural network model</li> <li>They are capable of applying subspace algorithms to the experimental identification of linear models for dynamic systems</li> <li>They can do the above using standard software tools (including the Matlab System Identification Toolbox)</li> </ul>				
Personal Competence					
Social Competence	Students can work in mixed gro	oups on specific problems	to arrive at joint solutions.		
Autonomy	Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.				
Workload in Hours	Independent Study Time 62, St	tudy Time in Lecture 28			
Credit points	3	_	_		
Course achievement	INONE				
Examination	Oral exam				
Examination duration and scale	30 min				
	Electrical Engineering: Special Elective Compulsory Mechatronics: Specialisation In				

	lechatronics: Specialisation System Design: Elective Compulsory iomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: lective Compulsory				
Assignment for	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective				
the Following	Compulsory				
Curricula	Biomedical Engineering: Specialisation Medical Technology and Control Theory:				
	Compulsory				
	Biomedical Engineering: Specialisation Management and Business Administration:				
	Elective Compulsory				
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective				
	Compulsory				
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory				

Course L0660: Linear and Nonlinear System Identification				
Тур	Lecture			
Hrs/wk	2			
СР	3			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Herbert Werner			
Language	EN			
Cycle	SoSe			
Content	<ul> <li>Prediction error method</li> <li>Linear and nonlinear model structures</li> <li>Nonlinear model structure based on multilayer perceptron network</li> <li>Approximate predictive control based on multilayer perceptron network model</li> <li>Subspace identification</li> </ul>			
Literature	<ul> <li>Lennart Ljung, System Identification - Theory for the User, Prentice Hall 1999</li> <li>M. Norgaard, O. Ravn, N.K. Poulsen and L.K. Hansen, Neural Networks for Modeling and Control of Dynamic Systems, Springer Verlag, London 2003</li> <li>T. Kailath, A.H. Sayed and B. Hassibi, Linear Estimation, Prentice Hall 2000</li> </ul>			

Courses									
<b>Title</b> Lagrangian transport ir	n turbul	ent flows (L	2301)		<b>Typ</b> Lecture		Hrs/wk	<b>CP</b> 3	
Computational Fluid Dy	namics	s - Exercises	in OpenFoa	m (L1375)	Recitation (small)	Section	1	1	
Computational Fluid Dy	namics	s in Process	Engineering	(L1052)	Lecture		2	2	
		rof. Michael Schlüter							
Admission Requirements	None								
Recommended Previous Knowledge	•		vledge in Fl	uid Mechanic nemical thern					
Educational Objectives	After t	aking part	successfull	y, students h	ave reached	the follo	wing learn	ing results	
Professional Competence				of the module					
Knowledge	<ul> <li>explain the the basic principles of statistical thermodynamics (ensembles simple systems)</li> <li>describe the main approaches in classical Molecular Modeling (Monte Carlo Molecular Dynamics) in various ensembles</li> <li>discuss examples of computer programs in detail,</li> <li>evaluate the application of numerical simulations,</li> <li>list the possible start and boundary conditions for a numerical simulation.</li> </ul>								
Skills	•	molecular solve prob set up a no perform a	mputer pro dynamics, lems by mo umerical gr simple num	grams for so blecular mode id, nerical simula a numerical	eling, tion with Op	·	ns by Mor	nte Carlo	
Personal Competence									
Social Competence	•	students,	int solution	s in mixed te	•				
Autonomy	•	on that ba	heir learnin sis,	g progress al sequences fo			wing steps	s of learnir	

Tvn	Lecture
Hrs/wk	
СР	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Alexandra von Kameke
Language	EN
Cycle	SoSe
	Contents
	- Common variables and terms for characterizing turbulence (energy spectra energy cascade, etc.)
	- An overview of Lagrange analysis methods and experiments in fluid mechanics
	- Critical examination of the concept of turbulence and turbulent structures.
	-Calculation of the transport of ideal fluid elements and associated analysis method (absolute and relative diffusion, Lagrangian Coherent Structures, etc.)
	- Implementation of a Runge-Kutta 4th-order in Matlab
	- Introduction to particle integration using ODE solver from Matlab
	- Problems from turbulence research
	- Application analytical methods with Matlab.
	Structure:
	- 14 units a 2x45 min.
	- 10 units lecture

- 4 Units Matlab Exercise- Go through the exercises Matlab, Peer2Peer? Explain solutions to your colleague

## Content

Learning goals:

Students receive very specific, in-depth knowledge from modern turbulence research and transport analysis. → Knowledge

The students learn to classify the acquired knowledge, they study approaches to further develop the knowledge themselves and to relate different data sources to each other. → Knowledge, skills

The students are trained in the personal competence to independently delve into and research a scientific topic. → Independence

Matlab exercises in small groups during the lecture and guided Peer2Peer discussion rounds train communication skills in complex situations. The mixture of precise language and intuitive understanding is learnt. → Knowledge, social competence

Required knowledge:

Fluid mechanics 1 and 2 advantageous

Programming knowledge advantageous

Bakunin, Oleg G. (2008): Turbulence and Diffusion. Scaling Versus Equations. Berlin [u. a.]: Springer Verlag.

Bourgoin, Mickaël; Ouellette, Nicholas T.; Xu, Haitao; Berg, Jacob; Bodenschatz, Eberhard (2006): The role of pair dispersion in turbulent flow. In: Science (New York, N.Y.) 311 (5762), S. 835-838. DOI: 10.1126/science.1121726.

Davidson, P. A. (2015): Turbulence. An introduction for scientists and engineers. Second edition. Oxford: Oxford Univ. Press.

Graff, L. S.; Guttu, S.; LaCasce, J. H. (2015): Relative Dispersion in the Atmosphere from Reanalysis Winds. In: J. Atmos. Sci. 72 (7), S. 2769-2785. DOI: 10.1175/JAS-D-14-0225.1.

Grigoriev, Roman (2011): Transport and Mixing in Laminar Flows. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA.

Haller, George (2015): Lagrangian Coherent Structures. In: Annu. Rev. Fluid Mech. 47 (1), S. 137-162. DOI: 10.1146/annurev-fluid-010313-141322.

Kameke, A. von; Huhn, F.; Fernández-García, G.; Muñuzuri, A. P.; Pérez-Muñuzuri, V. (2010): Propagation of a chemical wave front in a quasi-two-dimensional superdiffusive flow. In: Physical review. E, Statistical, nonlinear, and soft matter physics 81 (6 Pt 2), S. 66211. DOI: 10.1103/PhysRevE.81.066211.

Kameke, A. von; Huhn, F.; Fernández-García, G.; Muñuzuri, A. P.; Pérez-Muñuzuri, V. (2011): Double cascade turbulence and Richardson dispersion in a horizontal fluid flow induced by Faraday waves. In: Physical review letters 107 (7), S. 74502. DOI: 10.1103/PhysRevLett.107.074502.

Literature Kameke, A.v.; Kastens, S.; Rüttinger, S.; Herres-Pawlis, S.; Schlüter, M. (2019): How coherent structures dominate the residence time in a bubble wake: An experimental example. In: Chemical Engineering Science 207, S. 317-326. 10.1016/j.ces.2019.06.033.

Klages, Rainer; Radons, Günter; Sokolov, Igor M. (2008): Anomalous Transport: Wiley.

LaCasce, J. H. (2008): Statistics from Lagrangian observations. In: Progress in Oceanography 77 (1), S. 1-29. DOI: 10.1016/j.pocean.2008.02.002.

Neufeld, Zoltán; Hernández-García, Emilio (2009): Chemical and Biological Processes in Fluid Flows: PUBLISHED BY IMPERIAL COLLEGE PRESS AND DISTRIBUTED BY WORLD SCIENTIFIC PUBLISHING CO.

Onu, K.; Huhn, F.; Haller, G. (2015): LCS Tool: A computational platform for Lagrangian coherent structures. In: Journal of Computational Science 7, S. 26-36. DOI: 10.1016/j.jocs.2014.12.002.

Ouellette, Nicholas T.; Xu, Haitao; Bourgoin, Mickaël; Bodenschatz, Eberhard (2006): An experimental study of turbulent relative dispersion models. In: New J. Phys. 8 (6), S. 109. DOI: 10.1088/1367-2630/8/6/109.

Pope, Stephen B. (2000): Turbulent Flows. Cambridge: Cambridge University Press.

Rivera, M. K.; Ecke, R. E. (2005): Pair dispersion and doubling time statistics in two-dimensional turbulence. In: Physical review letters 95 (19), S. 194503. DOI: 10.1103/PhysRevLett.95.194503.

Vallis, Geoffrey K. (2010): Atmospheric and oceanic fluid dynamics. Fundamentals and large-scale circulation. 5. printing. Cambridge: Cambridge Univ. Press.

Course L1375: Com	putational Fluid Dynamics - Exercises in OpenFoam
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	<ul> <li>generation of numerical grids with a common grid generator</li> <li>selection of models and boundary conditions</li> <li>basic numerical simulation with OpenFoam within the TUHH CIP-Pool</li> </ul>
Literature	OpenFoam Tutorials (StudIP)

Course L1052: Com	nputational Fluid Dynamics in Process Engineering
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	<ul> <li>Introduction into partial differential equations</li> <li>Basic equations</li> <li>Boundary conditions and grids</li> <li>Numerical methods</li> <li>Finite difference method</li> <li>Finite volume method</li> <li>Time discretisation and stability</li> <li>Population balance</li> <li>Multiphase Systems</li> <li>Modeling of Turbulent Flows</li> <li>Exercises: Stability Analysis</li> <li>Exercises: Example on CFD - analytically/numerically</li> </ul>
Literature	Paschedag A.R.: CFD in der Verfahrenstechnik: Allgemeine Grundlagen und mehrphasige Anwendungen, Wiley-VCH, 2004 ISBN 3-527-30994-2.  Ferziger, J.H.; Peric, M.: Numerische Strömungsmechanik. Springer-Verlag, Berlin, 2008, ISBN: 3540675868.  Ferziger, J.H.; Peric, M.: Computational Methods for Fluid Dynamics. Springer, 2002, ISBN 3-540-42074-6

Module M0752	2: Nonlinear Dynamics						
Courses							
<b>Title</b> Nonlinear Dynamics (L	<b>Typ</b> Integrated Lecture	Hrs/wk 4	<b>CP</b> 6				
Module Responsible	Prof. Norbert Hoffmann						
Admission Requirements	None						
Recommended Previous Knowledge	<ul> <li>Linear Algebra</li> </ul>						
Educational Objectives	After taking part successfully, students l	nave reached the follo	owing learn	ing results			
Professional Competence							
Knowledge	Students are able to reflect existing term to develop and research new terms and		onlinear Dy	namics and			
Skills	students are able to apply existing methods and procesures of Nonlinear Dynamics and to develop novel methods and procedures.						
Personal Competence		in around					
Autonomy	Students can reach working results also in groups.  Students are able to approach given research tasks individually and to identify and collow up novel research tasks by themselves.						
Workload in Hours	Independent Study Time 124, Study Tim						
Credit points							
Course achievement	None						
Examination	Written exam						
Examination duration and scale	2 Hours						
Assignment for	Aircraft Systems Engineering: Specialisa International Management and Engineer Compulsory Mechanical Engineering and Managem Compulsory Mechatronics: Specialisation System Desertation Mechatronics: Specialisation Intelligent State Biomedical Engineering: Specialisation A Elective Compulsory Biomedical Engineering: Specialisation	ring: Specialisation II.  nent: Specialisation  sign: Elective Compul  Systems and Robotics  Artificial Organs and R	Mechatron  Mechatroni  sory  Elective (  Regenerativ	cs: Elective cs: Elective Compulsory ve Medicine:			
the Following Curricula	Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation Elective Compulsory Product Development, Materials and Compulsory Theoretical Mechanical Engineering: T Compulsory Theoretical Mechanical Engineering: Cor	Medical Technology Management and Bu Production: Core Technical Complemen	and Contusiness Add qualification	ministration: on: Elective se: Elective			

Course L0702: Non	Course L0702: Nonlinear Dynamics				
Тур	Typ Integrated Lecture				
Hrs/wk	4				
СР	6				
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56				
Lecturer	Prof. Norbert Hoffmann				
Language	DE/EN				
Cycle	SoSe				
Content	Fundamentals of Nonlinear Dynamics.				
Literature	S. Strogatz: Nonlinear Dynamics and Chaos. Perseus, 2013.				

Module M0605	5: Computational Struc	ctural Dynamic	cs					
Courses								
Title Computational Structu	ral Dynamics (L0282)	<b>Typ</b> Lecture		Hrs/wk	<b>CP</b> 4			
Computational Structu	-	Recitation (small)	Section	1	2			
Module Responsible	Prof. Alexander Düster							
Admission Requirements	None							
Recommended Previous Knowledge	Knowledge of partial differential	equations is recomm	ended.					
Educational Objectives	After taking part successfully, stu	udents have reached	the follo	wing learn	ing results			
Professional Competence								
Knowledge	<ul><li>dynamics.</li><li>+ explain the application of finit dynamics.</li><li>+ specify problems of computations.</li></ul>	+ give an overview of the computational procedures for problems of structural dynamics. + explain the application of finite element programs to solve problems of structural						
Skills	Students are able to + model problems of structural dynamics. + select a suitable solution procedure for a given problem of structural dynamics. + apply computational procedures to solve problems of structural dynamics. + verify and critically judge results of computational structural dynamics.							
Personal Competence								
Social Competence	Students are able to + solve problems in heterogeneous groups and to document the corresponding results.							
Autonomy	Students are able to + acquire independently knowled	dge to solve complex	problem	S.				
Workload in Hours	Independent Study Time 124, St	udy Time in Lecture 5	56					
Credit points	6							
Course achievement	None							
Examination								
Examination duration and scale								
Assignment for the Following Curricula		Modeling: Elective C mentary Course: Elec ngineering: Core qual ering: Technical Con	ompulsor tive Com ification:	y pulsory Elective C	ompulsory			

Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0282: Com	nputational Structural Dynamics
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Düster
Language	DE
Cycle	SoSe
Content	<ol> <li>Motivation</li> <li>Basics of dynamics</li> <li>Time integration methods</li> <li>Modal analysis</li> <li>Fourier transform</li> <li>Applications</li> </ol>
Literature	[1] KJ. Bathe, Finite-Elemente-Methoden, Springer, 2002. [2] J.L. Humar, Dynamics of Structures, Taylor & Francis, 2012.

Course L0283: Com	ourse L0283: Computational Structural Dynamics				
Тур	Recitation Section (small)				
Hrs/wk	1				
СР	2				
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14				
Lecturer	Prof. Alexander Düster				
Language	DE				
Cycle	SoSe				
Content	See interlocking course				
Literature	See interlocking course				

Courses									
Title Optimal and Robust Co	ontrol (L	_0658)			<b>Typ</b> Lect	ture		Hrs/wk	<b>CP</b> 3
Optimal and Robust Co	ontrol (L	_0659)			Reci	itation all)	Sectio	<sup>n</sup> 2	3
Module Responsible		lerbert W	erner						
Admission Requirements	None								
Recommended Previous Knowledge	•	State spa	ace metho	ds	response, e decompo		ıs)		
Educational Objectives	After t	aking par	t successf	ully, stud	ents have	reached	the follo	owing learn	ing results
Professional Competence									
Knowledge	•	solution of They can state estimate they can case of a They can lends itsee They can can guar. They under the they can guar.	of LQ probes explain explain and perform explain here explain explain explain here explain hantee stalderstand here explain here explai	how the mance conow an LC gn probler how mod st controll ow - base bility and phow analy	ty between H2 and H enstraints. QG design m. el uncertal er design ed on the s performane	n optima -infinity problem inty can mall gai ce for ar ynthesis	norms can be be report theore uncerta	feedback are used to a formulate resented in the a robustion of the control of th	ation for the and optima to represent d as special n a way that ast controlled dback loop
Skills	•	multivari They are form of a it. They are control le carrying They are system, a They are matrix in They car	able plant e capable a generalize capable coops into out a mixe capable capable capable e capable e capable equalities	models. of repres zed plant, of translat constrair ed-sensitiv of construitioning a r of formula (LMI), and	enting a Hand of us ing time a nts on clowity design an Lanixed-objecting analyd of using s	H2 or H- ing stan  nd frequ sed-loopFT unce ctive rob ysis and	infinity dard so ency do sensiti rtainty i oust con synthes LMI-sol	design profitware tool omain spec ivity functi model for a troller. sis conditio vers for so	oblem in the strong for solving ifications for solving and constant uncertainers as linearlying them. sools (Matla
Personal Competence									
Social Competence					-	•		-	
Autonomy					information information in the interior in the interior in the interior in the interior in the information i				cture notes

<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
the Following	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L0658: Opti	mal and Robust Control
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	<ul> <li>Optimal regulator problem with finite time horizon, Riccati differential equation</li> <li>Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system</li> <li>Kalman's identity, phase margin of LQR controllers, spectral factorization</li> <li>Optimal state estimation, Kalman filter, LQG control</li> <li>Generalized plant, review of LQG control</li> <li>Signal and system norms, computing H2 and H∞ norms</li> <li>Singular value plots, input and output directions</li> <li>Mixed sensitivity design, H∞ loop shaping, choice of weighting filters</li> <li>Case study: design example flight control</li> <li>Linear matrix inequalities, design specifications as LMI constraints (H2, H∞ and pole region)</li> <li>Controller synthesis by solving LMI problems, multi-objective design</li> <li>Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty</li> </ul>
Literature	<ul> <li>Werner, H., Lecture Notes: "Optimale und Robuste Regelung"</li> <li>Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994</li> <li>Skogestad, S. and I. Postlewhaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996</li> <li>Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988</li> <li>Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998</li> </ul>

Course L0659: Optimal and Robust Control			
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Herbert Werner		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0657	7: Computational Fluid [	Dynamics II				
Courses						
<b>Title</b> Computational Fluid D	ynamics II (L0237)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3		
Computational Fluid Dy	ynamics II (L0421)	Recitation (large)	Section 2	3		
Module Responsible	Prof. Thomas Rung					
Admission Requirements	INODE					
Recommended Previous Knowledge	Basics of computational and gener	al thermo/fluid dyna	nmics			
Educational Objectives	After taking part successfully, stud	ents have reached t	the following learr	ning results		
Professional Competence						
Knowledge	Establish a thorough understanding of Finite-Volume approaches. Familiarise with details of the theoretical background of complex CFD algorithms.					
Skills	evaluate, assess and benchmark d	Ability to manage of interface problems and build-up of coding skills. Ability to evaluate, assess and benchmark different solution options.				
Personal Competence						
· ·	Practice of team working during te	am exercises.				
Autonomy	Indenpendent analysis of specific s	solution approaches.				
<b>Workload in Hours</b>	Independent Study Time 124, Stud	ly Time in Lecture 5	6			
Credit points	6					
Course achievement	None					
Examination	Oral exam					
Examination duration and scale						
Assignment for the Following Curricula	Energy Systems: Core qualification Naval Architecture and Ocean Engi Theoretical Mechanical Engineeri Compulsory Theoretical Mechanical Engineering Process Engineering: Specialisation	ineering: Core qualif ng: Technical Com g: Core qualification	ication: Elective Color plementary Cour	se: Elective sory		

Course L0237: Computational Fluid Dynamics II				
Тур	Lecture			
Hrs/wk	2			
СР	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Thomas Rung			
Language	DE/EN			
Cycle	SoSe			
Content	Computational Modelling of complex single- and multiphase flows using higher- order approximations for unstructured grids and mehsless particle-based methods.			
Literature	1) Vorlesungsmanuskript und Übungsunterlagen  2) J.H. Ferziger, M. Peric: Computational Methods for Fluid Dynamics, Springer			

Course L0421: Computational Fluid Dynamics II			
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Thomas Rung		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M1156	5: Systems Engineering				
Courses					
<b>Title</b> Systems Engineering ( Systems Engineering (		<b>Typ</b> Lecture Recitation (large)	Section	Hrs/wk 3	<b>CP</b> 4 2
Module Responsible	Prof. Ralf God	(large)			
Admission Requirements					
Recommended Previous Knowledge	Basic knowledge in:  • Mathematics  • Mechanics  • Thermodynamics  • Electrical Engineering  • Control Systems  Previous knowledge in:  • Aircraft Cabin Systems				
Educational Objectives	After taking part successfully, students l	have reached	the follow	ving learn	ing results
Professional Competence					
Knowledge	Students are able to:  • understand systems engineering process models, methods and tools for the development of complex Systems  • describe innovation processes and the need for technology Management  • explain the aircraft development process and the process of type certification for aircraft  • explain the system development process, including requirements for systems reliability  • identify environmental conditions and test procedures for airborne Equipment  • value the methodology of requirements-based engineering (RBE) and model-based requirements engineering (MBRE)				
Skills	Students are able to: • plan the process for the development of complex Systems • organize the development phases and development Tasks • assign required business activities and technical Tasks • apply systems engineering methods and tools				
Personal Competence					
Social Competence	Students are able to: • understand their responsibilities w themselves with their role in the overall		elopment	team an	id integrate
Autonomy	Students are able to: • interact and communicate in a develo	pment team v	which has	distribute	ed tasks
Workload in Hours	Independent Study Time 124, Study Tim	ne in Lecture	56		
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and					

scale								
	Aircraft Systems Engineering: Core qualification: Compulsory							
	nternational Management and Engineering: Specialisation II. Aviation Systems:							
	Elective Compulsory							
	nternational Management and Engineering: Specialisation II. Product Development							
	and Production: Elective Compulsory							
	Mechatronics: Specialisation System Design: Elective Compulsory							
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory							
_	Product Development, Materials and Production: Specialisation Product							
_	Development: Compulsory							
Curricula	Product Development, Materials and Production: Specialisation Production: Elective							
	Compulsory							
	Product Development, Materials and Production: Specialisation Materials: Elective							
	Compulsory							
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective							
	Compulsory The author Machanical Engineering Creatistics Aircraft Customs Engineering							
	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering:							
	Elective Compulsory							

Course L1547: Syst	tems Engineering
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	
Cycle	SoSe
Content	The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integration of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineering process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known.  Key aspects of the course are processes for innovation and technology management, system design, system integration and certification as well as tools and methods for systems engineering:  Innovation processes  IP-protection  Technology management  Systems engineering  Aircraft program  Certification issues  Systems development  Safety objectives and fault tolerance Environmental and operating conditions  Tools for systems engineering  Requirements-based engineering (RBE)  Model-based requirements engineering (MBRE)
Literature	<ul> <li>Skript zur Vorlesung</li> <li>diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE)</li> <li>Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010</li> <li>NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007</li> <li>Hinsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation luftfahrttechnischer Betriebe. Springer, 2010</li> <li>De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010</li> <li>Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt. Verlag, 2008</li> </ul>

Course L1548: Systems Engineering			
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Ralf God		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M064:	1: Steam Genera	ators				
Courses						
Title Steam Generators (LO)			<b>Typ</b> Lecture Recitation	Hrs 3 Section 1	/wk	<b>CP</b> 5
Steam Generators (L02	214)		(large)	1		1
пезропзыне						
Admission Requirements	INODE					
Recommended Previous Knowledge	"Heat Transfer"     "Fluid Mochanic	s"	"			
Educational Objectives	After taking part succe	essfully, students h	ave reached	the following	learni	ing results
Professional Competence						
Knowledge	The students know the thermodynamic base principles for steam generators and their types. They are able to describe the basic principles of steam generators and sketch the combustion and fuel supply aspects of fossil-fuelled power plants. They can perform thermal design calculations and conceive the water-steam side, as well as they are able to define the constructive details of the steam generator. The students can describe and evaluate the operational behaviour of steam generators and explain these in the context of related disciplines.					
Skills	The students will be able, using detailed knowledge on the calculation, design, and construction of steam generators, linked with a wide theoretical and methodical foundation, to understand the main design and construction aspects of steam generators. Through problem definition and formalisation, modelling of processes, and training in the solution methodology for partial problems a good overview of this key component of the power plant will be obtained.					
	Within the framework of the exercise the students obtain the ability to draw the balances, and design the steam generator and its components. For this purpose small but close to lifelike tasks are solved, to highlight aspects of the design of steam generators.					
Personal Competence						
Social Competence	Especially during the e This animates the stu questions to further im	dents to reflect or	n their existir			
Autonomy	The students will be steam generator, with theoretical and pract potential effects from highlighted.	only the help of ical knowledge fi	smaller clue rom the lect	s, on their o	wn. Tl olidate	his way the ed and the
Workload in Hours	Independent Study Tin	ne 124, Study Tim	e in Lecture 5	66		
Credit points	6					
	Compulsor <b>B</b> onus	Form		escription		

Course achievement		5 %	Excercises		Den Studiere kleine Aufgal lösbar) zur Vorwoche Antworten üblicherweise gegeben we Zeichnungen, oder, in s	oe (in ca Vorlesu gestellt. als rden, ab Stic seltenen	. 5 min ng der Die müssen Freitext er auch chpunkte Fällen,
Examination	Written exa	m					
Examination duration and scale	120 min						
Assignment for the Following Curricula	i ( omnijisorv	Mechanical ,	Engineering:	Technical	Complementary	Course:	Elective

Course L0213: Stea	Course L0213: Steam Generators		
Тур	Lecture		
Hrs/wk			
СР	5		
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42		
Lecturer	Prof. Alfons Kather		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>Thermodynamics of steam</li> <li>Basic principles of steam generators</li> <li>Types of steam generators</li> <li>Fuels and combustion systems</li> <li>Coal pulverisers and coal drying</li> <li>Modes of operation</li> <li>Thermal analysis and design</li> <li>Fluid dynamics in steam generators</li> <li>Design of the water-steam side</li> <li>Construction aspects</li> <li>Stress analysis</li> <li>Feed water for steam generators</li> <li>Operating behaviour of steam Generators</li> </ul>		
Literature	<ul> <li>Dolezal, R.: Dampferzeugung. Springer-Verlag, 1985</li> <li>Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985</li> <li>Steinmüller-Taschenbuch: Dampferzeuger-Technik. Vulkan-Verlag, Essen, 1992</li> <li>Kakaç, Sadık: Boilers, Evaporators and Condensers. John Wiley &amp; Sons, New York, 1991</li> <li>Stultz, S.C. and Kitto, J.B. (Ed.): Steam - its generation and use. 40<sup>th</sup> edition, The Babcock &amp; Wilcox Company, Barberton, Ohio, USA, 1992</li> </ul>		

Course L0214: Steam Generators	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alfons Kather
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

## Module M1175: Special Topics of Ship Propulsionand Hydrodynamics of High Speed Water Vehicles

Courses				
<b>Title</b> Hydrodynamics of High Speed Water Vehicles (L1593) Special Topics of Ship Propulsion (L1589)		<b>Typ</b> Lecture Lecture	<b>Hrs/wk</b> 3 3	<b>CP</b> 3 3
Module Responsible	Prof. Moustafa Abdel-Maksoud			
Admission Requirements	INONE			
Recommended Previous Knowledge	Basic knowledge on ship resistance	, ship propulsion and	propeller theory	/
Educational Objectives	LATTER TAKING NART SUCCESSIUM STUGE	ents have reached th	e following learn	ing results
Professional Competence				
Knowledge	<ul> <li>Understand present research</li> <li>Explain the present state of t</li> <li>Apply given methodology to</li> <li>Evaluate the limits of the pre</li> <li>Identify possibilities to exten</li> <li>Evaluate the feasibility of fur</li> </ul>	the art for the topics approach given probesent ship propulsion d present methods a	considered lems systems	sion
Skills	Students are able to • select and apply suitable computing and simulation methods to determine the hydrodynamic characteristics of ship propulsion systems • model the behavior of ship propulsion systems under different operation conditions by using simplified methods • evaluate critically the investigation results of experimental or numerical investigations			
Personal Competence	Students are able to			
Social Competence	<ul> <li>solve problems in heterogen</li> </ul>		document the co	orresponding
Autonomy	Students are able to assess their kr	nowledge by means o	of exercises and	case studies
	Independent Study Time 96, Study	Time in Lecture 84		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
the Following	Naval Architecture and Ocean Engir Theoretical Mechanical Engineerir Compulsory Theoretical Mechanical Engineerin Compulsory	ng: Technical Compl	ementary Cour	se: Elective

Course L1593: Hydrodynamics of High Speed Water Vehicles		
Тур	Lecture	
Hrs/wk	3	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Prof. Moustafa Abdel-Maksoud	
Language	DE/EN	
Cycle	SoSe	
Content	<ol> <li>Resistance components of different high speed water vehicles</li> <li>Propulsion units of high speed vehicles</li> <li>Waves resistance in shallow and deep water</li> <li>Surface effect ships (SES)</li> <li>Hydrofoil supported vehicles</li> <li>Semi-displacement vehicles</li> <li>Planning vehicles</li> <li>Slamming</li> <li>Manoeuvrability</li> </ol>	
Literature	Faltinsen,O. M., Hydrodynamics of High-Speed Marine Vehicles, Cambridge University Press, UK, 2006	

Course L1589: Spe	cial Topics of Ship Propulsion
Тур	Lecture
Hrs/wk	3
СР	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	SoSe
Content	<ol> <li>Propeller Geometry</li> <li>Cavitation</li> <li>Model Tests, Propeller-Hull Interaction</li> <li>Pressure Fluctuation / Vibration</li> <li>Potential Theory</li> <li>Propeller Design</li> <li>Controllable Pitch Propellers</li> <li>Ducted Propellers</li> <li>Podded Drives</li> <li>Water Jet Propulsion</li> <li>Voith-Schneider-Propulsors</li> </ol>
Literature	<ul> <li>Breslin, J., P., Andersen, P., Hydrodynamics of Ship Propellers, Cambridge Ocean Technology, Series 3,         Cambridge University Press, 1996.</li> <li>Lewis, V. E., ed., Principles of Naval Architecture, Volume II Resistance, Propulsion and Vibration,         SNAME, 1988.</li> <li>N. N., International Confrrence Waterjet 4, RINA London, 2004</li> <li>N. N., 1st International Conference on Technological Advances in Podded Propulsion, Newcastle, 2004</li> </ul>

Courses					
<b>Title</b> Applied Humanoid Rob	otics (L1794)		ect-/problem- ed Learning	Hrs/wk	<b>CP</b> 6
Module		Dase	ed Learning		
Responsible	Patrick Göttsch				
Admission Requirements	None				
Recommended Previous Knowledge	<ul><li>Object oriented</li><li>Introduction to o</li><li>Control systems</li><li>Mechanics</li></ul>		ms and data str	ructures	
Educational Objectives	I After taking hart cuccectilly students have reached the following learning recults				
Professional Competence					
Knowledge	<ul> <li>Students can explain humanoid robots.</li> <li>Students can explain the basic concepts, relationships and methods forward- and inverse kinematics</li> <li>Students learn to apply basic control concepts for different tasks in humano robotics.</li> </ul>				
Skills	<ul><li>C++, and use the They are capab models if necessed.</li><li>They are capable.</li></ul>	lement models for huse models for robot not not not not not not not not not n	notion or other Natlab for simul the real robot s ods for solving	tasks. lation and t system. abstract p	esting the
Personal Competence					
Social Competence		elop joint solutions in appropriate feedbac own results			
Autonomy	sources, and to	e to obtain required ut in into the context ndently define tasks	of the lecture.	•	
Workload in Hours	Independent Study Tim	e 96, Study Time in Le	ecture 84		
Credit points	6				
Course achievement	None				
	Written elaboration				
Examination duration and scale	5-10 pages				
	Computer Science: Spe Mechatronics: Specialis Theoretical Mechanica	ntion Intelligent System	ms and Robotic	s: Elective (	Compulsor

Assignment for	Elective Compulsory
the Following	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
Curricula	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory

Course L1794: Applied Humanoid Robotics		
Тур	Project-/problem-based Learning	
Hrs/wk	6	
СР	6	
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84	
Lecturer	Patrick Göttsch	
Language	DE/EN	
Cycle	WiSe/SoSe	
Content	<ul> <li>Fundamentals of kinematics</li> <li>Static and dynamic stability of humanoid robotic systems</li> <li>Combination of different software environments (Matlab, C++, etc.)</li> <li>Introduction to the necessary software frameworks</li> <li>Team project</li> <li>Presentation and Demonstration of intermediate and final results</li> </ul>	
Literature	B. Siciliano, O. Khatib. "Handbook of Robotics. Part A: Robotics Foundations", Springer (2008)	

Module M1174: Automation Technology and Systems			
	Typ	Urc/wk	СР
y and Systems (L2329)	Lecture	4	4
y and Systems (L2331)	Project-/problem-	1	1
y and Systems (L2330)	_	ion 1	1
Prof. Thorsten Schüppstuhl			
None			
without major course assessment			
After taking part successfully, stude	ents have reached the fo	llowing learr	ing results
Students			
<ul> <li>know the characteristic components of an automation systems and have good understanding of their interaction</li> <li>know methods for a systematical analysis of automation tasks and are able to use them</li> <li>have special competences in industrial robot based automation systems</li> </ul>			
<ul> <li>analyze complex Automation</li> <li>develop application based complex</li> <li>design subsystems and integrated investigate and evaluate safe</li> <li>create simple programs for resident</li> </ul>	oncepts and solutions grate into one system ety of machinery obots and programmable	e logic contro	ollers
Students are able to			
- develop solutions in a produc	ction environment with	qualified p	ersonnel at
<ul> <li>generate programs for robots</li> <li>develop solutions for practice</li> <li>design safety concepts for au</li> </ul>	s and programmable logi e oriented tasks of autom utomation applications	nation indep	endently
	Time in Lecture 84		
6			
None			
Written exam			
	y and Systems (L2329) y and Systems (L2331) y and Systems (L2330)  Prof. Thorsten Schüppstuhl  None  without major course assessment  After taking part successfully, stude  Students  • know the characteristic corgood understanding of their expression in the late of the	y and Systems (L2329) y and Systems (L2331) y and Systems (L2330) Prof. Thorsten Schüppstuhl  None  without major course assessment  After taking part successfully, students have reached the fole of the components of an automate good understanding of their interaction • know the characteristic components of an automate good understanding of their interaction • know methods for a systematical analysis of automate use them • have special competences in industrial robot based at Students are able to • analyze complex Automation tasks • develop application based concepts and solutions • design subsystems and integrate into one system • investigate and evaluate safety of machinery • create simple programs for robots and programmable of design of circuit for pneumatic applications  Students are able to • find solutions for automation and handling tasks in groups - develop solutions in a production environment with technical level and represent decisions.  Students are able to • analyze automation tasks independently • generate programs for robots and programmable logical develop solutions for practice oriented tasks of autom design safety concepts for automation applications • assess consequences of their professional actions and Independent Study Time 96, Study Time in Lecture 84 6 None	y and Systems (L2329)  y and Systems (L2331)  Prof. Thorsten Schüppstuhl  None  Without major course assessment  After taking part successfully, students have reached the following learn good understanding of their interaction  k now methods for a systematical analysis of automation tasks an use them  have special competences in industrial robot based automation systems of every application based concepts and solutions  develop application based concepts and solutions  design subsystems and integrate into one system  investigate and evaluate safety of machinery create simple programs for robots and programmable logic control design of circuit for pneumatic applications  Students are able to  find solutions for automation and handling tasks in groups develop solutions in a production environment with qualified prechains are able to  analyze automation tasks independently generate programs for robots and programmable logic devices and edvelop solutions for practice oriented tasks of automation independent study Time 96, Study Time in Lecture 84  Mone

Examination duration and scale	120 min
Assignment for the Following Curricula	

Course L2329: Automation Technology and Systems	
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Thorsten Schüppstuhl
Language	DE
Cycle	SoSe
Content	
Literature	

Course L2331: Automation Technology and Systems		
Тур	Project-/problem-based Learning	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Thorsten Schüppstuhl	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L2330: Automation Technology and Systems		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Thorsten Schüppstuhl	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1281: Advanced Topics in Vibration					
Courses					
Title			Тур	Hrs/wk	СР
Advanced Topics in Vib	oration (L1743)		Project-/problem- based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	Vibration Theory				
Educational Objectives	LATTAR TAKINA NART CHAACCTHIIV CI	tudents h	ave reached the foll	lowing learr	ing results
Professional Competence					
Knowieuge	develop and research new terms and concepts.				
Skills	Students are able to apply existing methods and procesures of Advanced Vibrations and to develop novel methods and procedures.				
Personal Competence					
Social Competence	Students can reach working results	s also in gr	oups.		
Autonomy	Students are able to approach giv up novel research tasks by themse		ch tasks individually	and to ident	fy and follow
<b>Workload in Hours</b>	Independent Study Time 124, S	tudy Time	e in Lecture 56		
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale					
the Following	Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory				

Course L1743: Advanced Topics in Vibration		
Тур	Project-/problem-based Learning	
Hrs/wk	4	
СР	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Norbert Hoffmann, Merten Tiedemann, Sebastian Kruse	
Language	DE/EN	
Cycle	SoSe	
Content	Research Topics in Vibrations.	
Literature	Aktuelle Veröffentlichungen	

Module M1335	5: BIO II: Artificial Joint R	eplacement		
Courses				
<b>Title</b> Artificial Joint Replacer	ment (L1306)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic and	surgical techniques is r	ecommended	
Educational Objectives	After taking part successfully, stude	ents have reached the fo	ollowing learn	ing results
Professional Competence		t kinds of artificial limbe	S.	
	The students can explain the adva endoprotheses.			ent kinds of
Personal Competence				
Social Competence	The students are able to discuss iss and the teachers.	ues related to endopro	these with stu	udent mates
Autonomy	The students are able to acquire in information with respect to its credi		. They can als	so judge the
<b>Workload in Hours</b>	Independent Study Time 62, Study	Time in Lecture 28		
Credit points	3			
Course achievement	None			
	Written exam			
Examination duration and scale	90 min			
the Following	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Orientierungsstudium: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L1306: Arti	ficial Joint Replacement		
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Michael Morlock		
Language	DE		
Cycle			
	Inhalt (deutsch)		
Content	<ol> <li>EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes)</li> </ol>		
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)		
	3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate)		
	4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten)		
	5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren)		
	6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz)		
	7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)		
	8. DIE HAND (Anatomie, Biomechanik, Ge-lenkersatz)		
	9. TRIBOLOGIE NATÜRLICHER UND KÜNST-LICHER GELENKE (Korrosion, Reibung, Verschleiß)		
	Literatur:		
Literature	Kapandji, I: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.		
	Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994		
	Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febiger, Philadelphia, 1989.		
	Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.		
	Sobotta und Netter für Anatomie der Gelenke		

## Module M1339: Design optimization and probabilistic approaches in structural analysis

Courses									
<b>Title</b> Design Optimization a	and Prob	abilistic A	Approaches	in Structural	I	<b>Typ</b> Lecture		Hrs/wk	<b>CP</b> 3
Analysis (L1873)  Design Optimization and Probabilistic Approaches in Structural Recitation Section (large)				3					
-	i					(large)			
Module Responsible		Benedikt	Kriegesma	inn					
Admission Requirements	111111111111111111111111111111111111111								
Recommended Previous Knowledge	•	Technic Higher r	al mechani math	ics					
Educational Objectives		taking pa	art success	fully, stude	nts h	ave reached	the follow	ving learn	ing results
Professional Competence									
Knowledge		o G o G o C o T Reliabili o S o M o S robust C	Genetic algo Optimization Opology op Ity analysis Stochastic k Monte Carlo Gemi-analyt design optic Robustness	sed method orithms n with cons otimization coasics o methods cic approach mization measures	train hes	ts tion and reli	ability ana	alysis	
Skills		of struc Program	tures nming with entation of			nms and pro	babilistic ı	methods i	n the design
Personal Competence	=								
Social Competence		Team w Oral ex		of the the w	vork				
Autonomy		Familiar	rizing with	hods learne source code roaches an	e pro		ork of a ho	ome work	
Workload in Hours	Indep	endent S	tudy Time	124, Study	Time	e in Lecture	56		
Credit points	6								
Course achievement	INODE								
Examination	Writte	en elabor	ation						
Examination	ח								

duration and	· ·
scale	
	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory
Assignment for	Product Development, Materials and Production: Core qualification: Elective
the Following	
Curricula	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L1873: Des	ign Optimization and Probabilistic Approaches in Structural Analysis
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Benedikt Kriegesmann
Language	DE
Cycle	SoSe
Content	In the course the theoretic basics for design optimization and reliability analysis are taught, where the focus is on the application of such methods. The lectures will consist of presentations as well as computer exercises. In the computer exercises, the methods learned will be implemented in Matlab for understanding the practical realization.  The following contents will be considered:  • Design optimization  • Gradient based methods  • Genetic algorithms  • Optimization with constraints  • Topology optimization  • Reliability analysis  • Stochastic basics  • Monte Carlo methods  • Semi-analytic approaches  • robust design optimization  • Robustness measures  • Coupling of design optimization and reliability analysis
Literature	<ul> <li>[1] Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011.</li> <li>[2] Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley &amp; Sons New York/Chichester, UK, 2000.</li> </ul>

Course L1874: Design Optimization and Probabilistic Approaches in Structural Analysis				
Тур	Recitation Section (large)			
Hrs/wk	2			
СР	3			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Benedikt Kriegesmann			
Language	DE			
Cycle	SoSe			
Content	Matlab exercises complementing the lecture			
Literature	siehe Vorlesung			

Courses				
<b>Title</b> Compilers for Embedde	ed Systems (L1692)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b>
Compilers for Embeddo		Project-/problem- based Learning	1	2
Module Responsible	Prof. Heiko Falk			
Admission Requirements	None			
Recommended Previous Knowledge	Module "Embedded Systems"  C/C++ Programming skills			
Educational Objectives	After taking part successfully, stud	ents have reached the fo	llowing learn	ing results
Professional Competence				
Knowledge	The relevance of embedded systems increases from year to year. Within such systems, the amount of software to be executed on embedded processors grows continuously due to its lower costs and higher flexibility. Because of the particular application areas of embedded systems, highly optimized and application-specific processors are deployed. Such highly specialized processors impose high demands on compilers which have to generate code of highest quality. After the successful attendance of this course, the students are able  • to illustrate the structure and organization of such compilers, • to distinguish and explain intermediate representations of various abstraction levels, and • to assess optimizations and their underlying problems in all compiler phases.			
Skills	After successful completion of the course, students shall be able to translate high level program code into machine code. They will be enabled to assess which kind code optimization should be applied most effectively at which abstraction level (e.g., source or assembly code) within a compiler.  While attending the labs, the students will learn to implement a fully functional compiler including optimizations.			
Personal Competence	Students are able to solve similar	problems alone or in a c	iroup and to	present tl
Social Competence	results accordingly.	problems dione of in a g	,. Jap ana to	present ti

Autonomy	associate this knowledge with other classes.
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course I 1692: Com	pilers for Embedded Systems
	Lecture
Hrs/wk	
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Heiko Falk
Language	DE/EN
Cycle	SoSe
Content	<ul> <li>Introduction and Motivation</li> <li>Compilers for Embedded Systems - Requirements and Dependencies</li> <li>Internal Structure of Compilers</li> <li>Pre-Pass Optimizations</li> <li>HIR Optimizations and Transformations</li> <li>Code Generation</li> <li>LIR Optimizations and Transformations</li> <li>Register Allocation</li> <li>WCET-Aware Compilation</li> <li>Outlook</li> </ul>
Literature	<ul> <li>Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2<sup>nd</sup> Edition, Springer, 2012.</li> <li>Steven S. Muchnick. Advanced Compiler Design and Implementation. Morgan Kaufmann, 1997.</li> <li>Andrew W. Appel. Modern compiler implementation in C. Oxford University Press, 1998.</li> </ul>

Course L1693: Com	Course L1693: Compilers for Embedded Systems		
Тур	Project-/problem-based Learning		
Hrs/wk	1		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Heiko Falk		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
	es of fibre-polymer-composites (L1894) mer-composites (L1893)	<b>Typ</b> Lecture Lecture	<b>Hrs/wk</b> 2 2	<b>CP</b> 3 3
Module Responsible	Prof. Bodo Fiedler			
Admission Requirements	None			
Recommended Previous Knowledge	Basics: chemistry / physics / materials	science		
Educational Objectives	After taking part successfully, students	have reached th	e following learr	ing results
Professional Competence				
Knowledge	Students can use the knowledge of constituents to play (fiber / matrix) and They can explain the complex relations the interactions of chemical structure different fiber types, including to explenvironmental protection).	I define the necessifies structure-presented of the polyment	ssary testing and operty relationsl s, their processi	d analysis. hip and ing with th
Skills	<ul> <li>• using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.</li> <li>• approximate sizing using the network theory of the structural elements implement and evaluate.</li> <li>• selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.</li> </ul>			
Personal Competence				
competence	Students can			
Social Competence	<ul> <li>arrive at funded work results in I</li> <li>provide appropriate feedback ar constructively.</li> </ul>		•	
Autonomy	Students are able to - assess their own strengths and weaknesses assess their own state of learning in specific terms and to define further work steps on this basis assess possible consequences of their professional activity.			
	Independent Study Time 124, Study Ti	me in Lecture 56		
Credit points Course achievement	None			

Examination	Written exam
Examination duration and scale	180 min
the Following	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory Mechanical Engineering and Management: Core qualification: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course I 1894: Stru	icture and properties of fibre-polymer-composites
	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler
Language	EN
Cycle	SoSe
Content	<ul> <li>Microstructure and properties of the matrix and reinforcing materials and their interaction</li> <li>Development of composite materials</li> <li>Mechanical and physical properties</li> <li>Mechanics of Composite Materials</li> <li>Laminate theory</li> <li>Test methods</li> <li>Non destructive testing</li> <li>Failure mechanisms</li> <li>Theoretical models for the prediction of properties</li> <li>Application</li> </ul>
Literature	Hall, Clyne: Introduction to Composite materials, Cambridge University Press Daniel, Ishai: Engineering Mechanics of Composites Materials, Oxford University Press Mallick: Fibre-Reinforced Composites, Marcel Deckker, New York

Course L1893: Design with fibre-polymer-composites				
Тур	Lecture			
Hrs/wk	2			
СР	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Bodo Fiedler			
Language	EN			
Cycle	SoSe			
Content	Designing with Composites: Laminate Theory; Failure Criteria; Design of Pipes and Shafts; Sandwich Structures; Notches; Joining Techniques; Compression Loading; Examples			
Literature	Konstruieren mit Kunststoffen, Gunter Erhard , Hanser Verlag			

Module M1306	6: Control Lab C			
Courses				
Title Control Lab IX (L1836) Control Lab VII (L1834) Control Lab VIII (L1835)	)	<b>Typ</b> Practical Course Practical Course Practical Course	Hrs/wk 1 1 1	<b>CP</b> 1 1 1
Module Responsible	I Prof Harnart Warnar			
Admission Requirements	LNODE			
Recommended Previous Knowledge	H2 and H-infinity optimal control			
Educational Objectives	After taking part successfully, student	s have reached the fol	lowing learn	ing results
Professional Competence				
Knowledge	<ul> <li>Students can explain the differential value</li> </ul>		tion of a co	ontrol lop in
Skills	<ul> <li>Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis</li> <li>They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers</li> <li>They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers</li> <li>They are capable of representing model uncertainty, and of designing and implementing a robust controller</li> <li>They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers</li> </ul>			
Personal Competence				İ
Social Competence	Students can work in teams results	to conduct experime	nts and do	cument the
Autonomy	<ul> <li>Students can independently carry out simulation studies to design and validate control loops</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 48, Study Tir	me in Lecture 42		
Credit points	3			
Course achievement	None			
Examination	Written elaboration			
Examination duration and scale	1			

	Electrical Engineering: Specialisation Control and Power Systems Engineering:
	Elective Compulsory
Assignment for	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
the Following	Mechatronics: Specialisation System Design: Elective Compulsory
Curricula	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory

Course L1836: Control Lab IX		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Herbert Werner, Patrick Göttsch, Adwait Datar	
Language	EN	
Cycle	WiSe/SoSe	
Content	One of the offered experiments in control theory.	
Literature	Experiment Guides	

Course L1834: Control Lab VII		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Herbert Werner, Patrick Göttsch	
Language	EN	
Cycle	WiSe/SoSe	
	One of the offered experiments in control theory.	
Literature	Experiment Guides	

Course L1835: Control Lab VIII		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Herbert Werner, Patrick Göttsch, Adwait Datar	
Language	EN	
Cycle	WiSe/SoSe	
	One of the offered experiments in control theory.	
Literature	Experiment Guides	

Module M1239	9: Experimental Micro- and	Nanomec	hanics		
Courses					
•	nd Nanomechanics (L1673)	<b>Typ</b> Lecture Recitation	Hrs/wk 2 Section 1	<b>CP</b> 4	
Experimental Micro- ar	nd Nanomechanics (L1674)	(small)	1	2	
Module Responsible	Dr. Erica Lilleodden				
Admission Requirements	None				
	Basics in Materials Science I/II, Mechan Materials Science	ical Properties	s, Phenomena and	Methods in	
Educational Objectives	After taking part successfully, students h	nave reached	the following learn	ing results	
Professional					
Competence	Students are able to describe the prin	cinles of med	hanical behavior (	en stress	
	strain, modulus, strength, hardening, fai			e.g., scress,	
Knowledge	Students can explain the principles of characterization methods used for investigating microstructure (e.g., scanning electron microscopy, x-ray diffraction)				
	They can describe the fundamental relations between microstructure and mechanical properties.				
Skills	Students are capable of using standardized calculation methods to calculate and evaluate mechanical properties (modulus, strength) of different materials under varying loading states (e.g., uniaxial stress or plane strain).				
Personal Competence					
Social Competence	Students can provide appropriate feed performance constructively.	dback and ha	andle feedback or	n their own	
	Students are able to				
	- assess their own strengths and weaknesses				
Autonomy	- assess their own state of learning in specific terms and to define further work steps on this basis guided by teachers.				
	- to be able to work independently based on lectures and notes to solve problems, and to ask for help or clarifications when needed				
Workload in Hours	I Independent Study Time 138, Study Tim	e in Lecture 4	2		
Credit points					
Course achievement	None				
	Written exam				
Examination duration and scale					
Assignment for the Following	Materials Science: Specialisation Nano a Theoretical Mechanical Engineering: Compulsory Theoretical Mechanical Engineering: T	Specialisation	Materials Science	ce: Elective	
	Compulsory				

Course L1673: Expe	erimental Micro- and Nanomechanics
Тур	Lecture
Hrs/wk	2
СР	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Erica Lilleodden
Language	DE/EN
Cycle	SoSe
Content	This class will cover the principles of mechanical testing at the micron and nanometer scales. A focus will be made on metallic materials, though issues related to ceramics and polymeric materials will also be discussed. Modern methods will be explored, along with the scientific questions investigated by such methods.  • Principles of micromechanics  • Motivations for small-scale testing  • Sample preparation methods for small-scale testing  • General experimental artifacts and quantification of measurement resolution  • Complementary structural analysis methods  • Electron back scattered diffraction  • Transmission electron microscopy  • Micro-Laue diffraction  • Nanoindentation-based testing  • Principles of contact mechanics  • Berkovich indentation  ■ Loading geometry  ■ Governing equations for analysis of stress & strain  ■ Case study:  ■ Indentation size effects  • Microcompression  ■ Loading geometry  ■ Governing equations for analysis of stress & strain  ■ Case study:  ■ Size effects in yield strength and hardening  • Microbeam-bending  ■ Loading geometry  ■ Governing equations for analysis of stress & strain  ■ Case study:  ■ Fracture strength & toughness
Literature	Vorlesungsskript Aktuelle Publikationen

Course L1674: Experimental Micro- and Nanomechanics		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Dr. Erica Lilleodden	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1226	6: Mechanical Properties			
Courses				
Title Tyl Mechanical Behaviour of Brittle Materials (L1661) Lec Dislocation Theory of Plasticity (L1662) Lec			Hrs/wk CP 2 3 2 3	
Admission Requirements	None			
Recommended Previous Knowledge	Basics in Materials Science I/II			
Educational Objectives	After taking part successfully, stude	ents have reached the	e following learning results	
Professional Competence				
Knowledge	Students can explain basic principles of crystallography, statics (free body diagrams, tractions) and thermodynamics (energy minimization, energy barriers, entropy)			
Skills		Students are capable of using standardized calculation methods: tensor calculations, derivatives, integrals, tensor transformations		
Personal Competence				
Social Competence	Students can provide appropriate feedback and handle feedback on their own performance constructively.			
Autonomy	Students are able to  - assess their own strengths and weaknesses  - assess their own state of learning in specific terms and to define further work steps on this basis guided by teachers.  - work independently based on lectures and notes to solve problems, and to ask for help or clarifications when needed			
Workload in Hours	Independent Study Time 124, Study	/ Time in Lecture 56		
Credit points	· · · · · · · · · · · · · · · · · · ·			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
Assignment for the Following Curricula	Compulsory  Dradust Davidenment Materials	anagement: Specialing and Production described and Production: and Production:	: Specialisation Product lisation Production: Elective Specialisation Materials:	

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1661: Med	hanical Behaviour of Brittle Materials		
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Gerold Schneider		
Language	DE/EN		
Cycle	SoSe		
	Theoretical Strength Of a perfect crystalline material, theoretical critical shear stress		
	Real strength of brittle materials Energy release reate, stress intensity factor, fracture criterion		
	Scattering of strength of brittle materials Defect distribution, strength distribution, Weibull distribution		
	Heterogeneous materials I Internal stresses, micro cracks, weight function,		
	<b>Heterogeneous materials II</b> Toughening mechanisms: crack bridging, fibres		
Content	Heterogeneous materials III Toughening mechanisms. Process zone		
	Testing methods to determine the fracture toughness of brittle materials		
	R-curve, stable/unstable crack growth, fractography		
	Thermal shock		
	Subcritical crack growth) v-K-curve, life time prediction		
	Kriechen		
	Mechanical properties of biological materials		
	Examples of use for a mechanically reliable design of ceramic components		
	D R H Jones, Michael F. Ashby, Engineering Materials 1, An Introduction to Properties, Applications and Design, Elesevier		
Literature	D.J. Green, An introduction to the mechanical properties of ceramics", Cambridge University Press, 1998		
	B.R. Lawn, Fracture of Brittle Solids", Cambridge University Press, 1993		
	D. Munz, T. Fett, Ceramics, Springer, 2001		
	D.W. Richerson, Modern Ceramic Engineering, Marcel Decker, New York, 1992		

Course L1662: Dislocation Theory of Plasticity			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Dr. Erica Lilleodden		
Language			
Cycle	SoSe		
	This class will cover the principles of dislocation theory from a physical metallurgy perspective, providing a fundamental understanding of the relations between the strength and of crystalline solids and distributions of defects.		
Content	We will review the concept of dislocations, defining terminology used, and providing an overview of important concepts (e.g. linear elasticity, stress-strain relations, and stress transformations) for theory development. We will develop the theory of dislocation plasticity through derived stress-strain fields, associated self-energies, and the induced forces on dislocations due to internal and externally applied stresses. Dislocation structure will be discussed, including core models, stacking faults, and dislocation arrays (including grain boundary descriptions). Mechanisms of dislocation multiplication and strengthening will be covered along with general principles of creep and strain rate sensitivity. Final topics will include non-FCC dislocations, emphasizing the differences in structure and corresponding implications on dislocation mobility and macroscopic mechanical behavior; and dislocations in finite volumes.		
Literature	Vorlesungsskript Aktuelle Publikationen Bücher: Introduction to Dislocations, by D. Hull and D.J. Bacon Theory of Dislocations, by J.P. Hirth and J. Lothe Physical Metallurgy, by Peter Hassen		

Module M1238	3: Quantum Mechanics of So	lids		
Courses				
<b>Title</b> Quantum Mechanics of Quantum Mechanics of		Typ Lecture Recitation (small)	Hrs/wk 2 Section 1	<b>CP</b> 4 2
Module Responsible	Prof. Stefan Müller	(Silidil)		
Admission Requirements	<u> </u>			
Recommended Previous Knowledge	Knowledge of advanced mathematics like analysis, linear algebra, differential equations and complex functions, e.g., Mathematics I-IV Knowledge of mechanics and physics, particularly solid state physics, e.g., Materials Physics			
Educational Objectives	After taking part successfully, students h	ave reached the	e following learn	ing results
Professional Competence	The master students will be able to expla the basics of quantum mechanics. the importance of quantum physics for		n of materials pr	operties.
Knowledge	correlations between on quantum mechanics based phenomena between individual atoms and macroscopic properties of materials.  The master students will then be able to connect essential materials properties in engineering with materials properties on the atomistic scale in order to understand these connections.			
Skills	After attending this lecture the studentsperform materials design on a quantum		asis.	
Personal Competence				
Social Competence	The students are able to discuss compe with experts from fields such as physics a	• •		sed subjects
Autonomy	The students are able to independently problems. They can also acquire the complex questions with a quantum mech	knowledge the	y need to deal	with more
<b>Workload in Hours</b>	Independent Study Time 138, Study Time	e in Lecture 42		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale				
	Materials Science: Specialisation Nano ar	nd Hybrid Mater	ials: Elective Co	mpulsory

<b>Assignment for</b>	Materials Sc	ience: Specia	alisation Mode	ling: Electi	ve Co	mpulsory		
the Following	Theoretical	Mechanical	Engineering:	Specialis	ation	Materials	Science:	Elective
Curricula	Compulsory							
	Theoretical	Mechanical	Engineering:	Technical	Com	plementary	Course:	Elective
	Compulsory							

Course L1675: Qua	ntum Mechanics of Solids
Тур	Lecture
Hrs/wk	2
СР	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Stefan Müller
Language	DE/EN
Cycle	SoSe
Content	1. Introduction 1.1 Relevance of Quantum Mechanics 1.2 Classification of Solids 2. Foundations of Quantum Mechanics 2.1 Reminder: Elements of Classical Mechanics 2.2 Motivation for Quantum Mechanics 2.3 Particle-Wave Duality 2.4 Formalism 3. Elementary QM Problems 3.1 Onedimensional Problems of a Particle in a Potential 3.2 Two-Level System 3.3 Harmonic Oscillator 3.4 Electrons in a Magnetic Field 3.5 Hydrogen Atom 4. Quantum Effects in Condensed Matter 4.1 Preliminary 4.2 Electronic Levels 4.3 Magnetism 4.4 Superconductivity 4.5 Quantum Hall Effect
	Physik für Ingenieure, Hering/Martin/Stohrer, Springer Atom- und Quantenphysik, Haken/Wolf, Springer
Literature	Grundkurs Theoretische Physik 5 1, Nolting, Springer Electronic Structure of Materials, Sutton, Oxford
	Materials Science and Engineering: An Introduction, Callister/Rethwisch, Edition 9, Wiley

Course L1676: Qua	Course L1676: Quantum Mechanics of Solids			
Тур	Recitation Section (small)			
Hrs/wk	1			
СР	2			
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14			
Lecturer	Prof. Stefan Müller			
Language	DE/EN			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M1237	7: Methods in Theoret	tical Materials S	cience				
Courses							
	l Materials Science (L1677) l Materials Science (L1678)	<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 1	<b>CP</b> 4 2			
Module Responsible	Prof. Stefan Müller	(Sindin)					
Admission Requirements	None						
Recommended Previous Knowledge	Knowledge of advanced mathematics like analysis, linear algebra, differential equations and complex functions, e.g., Mathematics I-IV Knowledge of physics, particularly solid state physics, e.g., Materials Physics						
Educational Objectives	After taking part successfully, s	students have reached t	the following learn	ing results			
Professional Competence							
Knowledge	The master students will be able to explain how different modeling methods work. assess the field of application of individual methodological approaches. evaluate the strengths and weaknesses of different methods.  The students are thereby able to assess which method is best suited to solve a scientific problem and what accuracy can be expected from the simulation results.						
Skills	After completing the module, the students are able toselect the most suitable modeling method as a function of various parameters such as length scale, time scale, temperature, material type, etc						
Personal Competence Social Competence							
Autonomy	The students are able toassess their own strengths and weaknessesacquire the knowledge they need on their own.						
Workload in Hours	Independent Study Time 138, S	Study Time in Lecture 4	2				
Credit points							
Course achievement	None						
Examination Examination							

I	duration and								
I.	scale								
		Materials Sc	ience: Specia	alisation Mode	ling: Electi	ve Co	mpulsory		
	Assignment for	Theoretical	Mechanical	Engineering:	Specialis	ation	Materials	Science:	Elective
	the Following	Compulsory							
	Curricula	Theoretical	Mechanical	Engineering:	Technical	Com	plementary	Course:	Elective
		Compulsory							

Course L1677: Methods in Theoretical Materials Science						
Тур	Lecture					
Hrs/wk						
СР	4					
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28					
Lecturer	Prof. Stefan Müller					
Language	DE/EN					
Cycle	SoSe					
Content	<ol> <li>Introduction</li> <li>Classification of Modelling Approaches and the Solid State</li> <li>Quantum Mechanical Approaches</li> <li>Electronic states: Atoms, Molecules, Solids</li> <li>Density Functional Theory</li> <li>Spin-Dynamics</li> <li>Thermodynamic Approaches</li> <li>Thermodynamic Potentials</li> <li>Alloys</li> <li>Cluster Expansion</li> <li>Monte-Carlo-Methods</li> </ol>					
Literature	Solid State Physics, Ashcroft/Mermin, Saunders College  Computational Physics, Thijsen, Cambridge  Computational Materials Science, Ohno et al Springer  Materials Science and Engineering: An Introduction, Callister/Rethwisch, Edition 9, Wiley					

Course L1678: Met	Course L1678: Methods in Theoretical Materials Science			
Тур	Recitation Section (small)			
Hrs/wk	1			
СР	2			
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14			
Lecturer	Prof. Stefan Müller			
Language	DE/EN			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M1233	3: Numerical Method	s in Shi	p Design		
Courses					
<b>Title</b> Numerical Methods in Sumerical Methods in S			<b>Typ</b> Lecture Project-/problem-based Learning	<b>Hrs/wk</b> 2 2	<b>CP</b> 4 2
Module Responsible	Prof. Stefan Krüger				
Admission Requirements	None				
Recommended Previous Knowledge					
Educational Objectives	After taking part successfully,	, students h	ave reached the fol	lowing learn	ning results
Professional Competence <i>Knowledge</i> <i>Skills</i>					
Personal Competence Social Competence					
Autonomy Workload in Hours	Independent Study Time 124,	Study Time	e in Lecture 56		
Credit points					
Course achievement	None				
Examination	Oral exam				
Examination duration and scale					
the Following	Naval Architecture and Ocear Theoretical Mechanical Engi Compulsory Theoretical Mechanical Engi Compulsory	neering: Te	echnical Compleme	ntary Cour	se: Elective

Course L1271: Num	nerical Methods in Ship Design
Тур	Lecture
Hrs/wk	2
СР	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Stefan Krüger
Language	DE
Cycle	SoSe
	The lecture starts with the definition of the early design phase and the importance of first principle approaches. The reasons for process reengineering when such kinds of methods are introduced is demonstrated. Several numerical modelling techniques are introduced and discussed for the following design relevant topics:  - Hullform representation, fairing and interpolation  - Hullform design by modifying parent hulls  - Modelling of subdivison  - Volumetric and stability calculations  - Mass distributions and longitudinal strength  - Hullform Design by CFD- techniques  - Propulsor and Rudder Design by CFD Techniques
Literature	Skript zur Vorlesung.

Course L1709: Numerical Methods in Ship Design				
Тур	Project-/problem-based Learning			
Hrs/wk	2			
СР	2			
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Stefan Krüger			
Language	DE			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M0623	3: Intellige	nt Sys	stems in Me	dicine		
Courses						
Title				Тур	Hrs/wk	СР
Intelligent Systems in				Lecture	2	3
Intelligent Systems in				Project Seminar Recitation Section	2 n	2
Intelligent Systems in	Medicine (L0333)			(small)	1	1
Module Responsible	Prof. Alexander	r Schlaef	er			
Admission Requirements	None					
Recommended Previous Knowledge	<ul><li>principle</li><li>principle</li></ul>	es of stoc es of prog	h (algebra, analys hastics gramming, Java/C- mming skills			
Educational Objectives	After taking pa	rt succes	ssfully, students h	ave reached the follo	wing learn	ing results
Professional Competence						
Knowledge	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.					
Skills	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.					
Personal Competence	The students d	liscuss th	ne results of othe	r groups, provide hel	pful feedb	ack and car
Social Competence	incoorporate fe	edback i	into their work.			
Autonomy			ct their knowledg esults in an approp	e and document the priate manner.	results of	f their work
Workload in Hours	Independent St	tudy Tim	e 110, Study Time	e in Lecture 70		
Credit points	6					
Course achievement	Yes 10	%	Form Written elaborati Presentation	<b>Descript</b> on	ion	
Examination	Written exam					
Examination duration and scale						
Assignment for	Electrical Engir Mechatronics: S Biomedical Eng Elective Compu Biomedical En	neering: Specialis Specialis gineering ulsory	Specialisation Mec ation Intelligent S : Specialisation A	ligence Engineering: dical Technology: Elec ystems and Robotics: rtificial Organs and R Implants and End	ctive Comp : Elective C legenerativ	oulsory Compulsory ve Medicine:

the Following	Biomedical Engineering: Specialisation Medical Technology and Control Theory:
Curricula	Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology:
	Elective Compulsory

Course L0331: Intelligent Systems in Medicine		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>methods for search, optimization, planning, classification, regression and prediction in a clinical context</li> <li>representation of medical knowledge</li> <li>understanding challenges due to clinical and patient related data and data acquisition</li> <li>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</li> </ul>	
Literature	Russel & Norvig: Artificial Intelligence: a Modern Approach, 2012 Berner: Clinical Decision Support Systems: Theory and Practice, 2007 Greenes: Clinical Decision Support: The Road Ahead, 2007 Further literature will be given in the lecture	

Course L0334: Intelligent Systems in Medicine		
Тур	Project Seminar	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0333: Intelligent Systems in Medicine	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0658	3: Innovative CFD	Approache	:S		
Courses					
Title			Typ	Hrs/wk	СР
	ve CFD Methods in Research	and	Тур	•	
Development (L0239)			Lecture	2	3
Application of Innovation Development (L1685)	ve CFD Methods in Research		Recitation (small)	Section 2	3
Module Responsible	Prof. Thomas Rung				
Admission Requirements	None				
	Attendance of a computat	tional fluid dynai	mics course (C	CFD1/CFD2)	
	Competent knowledge computational thermo/flu		analysis in	addition to g	eneral and
Educational Objectives	After taking part successf	ully, students ha	ave reached th	e following learn	ing results
Professional					
Competence					
Knowledge	describe the fundamental	thed Particle-Hyd s of simulation-b	drodynamics, pased optimisa	Finite-Volume me ation.	ethods) and
Skills	Student is able to identify basis.	/ an appropriate	CFD-based so	olution strategy o	n a jusitfied
Personal					
Competence			alata ar a la tituda a	laama ka laad ka	
Social Competence	Student should practice hand present solutions to e		rking abilities,	learn to lead te	am sessions
Autonomy	Student should be able independently,	to structure a	and perform	a simulation-ba	sed project
Workload in Hours	Independent Study Time	124, Study Time	in Lecture 56		
Credit points	6				
Course achievement		<b>orm</b> Vritten elaboratio		scription	
Examination	Oral exam				
Examination duration and scale					
Assignment for the Following Curricula	Energy Systems: Core qua Naval Architecture and Od Ship and Offshore Techno Theoretical Mechanical I Compulsory Theoretical Mechanical Compulsory Theoretical Mechanical E Compulsory Process Engineering: Spec	cean Engineering logy: Core qualit Engineering: Teo Engineering: S ngineering: Spec	g: Core qualification: Electichnical Compoperialisation	cation: Elective Cove Compulsory lementary Course Energy System ulation Technolo	se: Electivens: Elective

Course L0239: Application of Innovative CFD Methods in Research and Development		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Thomas Rung	
Language	DE/EN	
Cycle	WiSe	
Content	Computational Optimisation, Parallel Computing, Efficient CFD-Procedures for GPU Archtiectures, Alternative Approximations (Lattice-Boltzmann Methods, Particle Methods), Fluid/Structure-Interaction, Modelling of Hybrid Continua	
Literature	Vorlesungsmaterialien /lecture notes	

Course L1685: Application of Innovative CFD Methods in Research and Development		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Thomas Rung	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

## Module M1037: Steam Turbines in Energy, Environmental and Power Train Engineering

Courses				
Title		Тур	Hrs/wk	СР
	rgy, environmental and Power Train	Lecture	3	5
Engineering (L1286) Steam turbines in ene Engineering (L1287)	rgy, environmental and Power Train	Recitation (small)	Section 1	1
Module Responsible	Prof. Alfons Kather			
Admission Requirements	LNANA			
Recommended Previous Knowledge	"Technical Thermodynamics I     "Fluid Mochanics"			
Educational Objectives	Latter taking part successfully studer	nts have reached t	he following learn	ing results
Professional Competence				
Knowledge	After successful completion of the m     name and identify the varieturbines     describe and explain the key of turbines     classify different construction according to size and operating describe the thermodynamic	ous parts and cooperating condition types and differency ranges processes and the latter a turbine stage and the operating in the operating in aspects and devenstruction characteristic	onstructive group  Ins for the applicate  Intiate among stem  It constructive and  It a stage assemble  It on a stage and the  It is a stage and the  It is a stage and the of   os of steam ion of steam am turbines operational ly constructive rmodynamic bine types	
Skills	In the module the students learn the design and operational evaluation confidence in seeking optimisations.  • obtain the ability to analyse to be utilised thermodynamically viewpoints  • can evaluate the performant energy sources, for supplying electricity grid  • on the basis of the impact components, can describe prevention  • can describe the key require Thermal Power Plants, based legislative frameworks.	n of complex plant of they specifically: the potential of variety, from the energine and technical plant of power plant of the precautions of the precautions.	ant, and gain in rious energy source getic-economic are limitations in usualancing reserve properation on the lary principles for Management and	n particular ces that can nd technical sing various ower to the integrity of or damage d Design of

Personal Competence Social Competence	In the module the students learn:  • to work together with others whilst seeking a solution • to assist each other in problem solving • to conduct discussions • to present work results • to work respectfully within the team.
Autonomy	In the module the students learn the independent working of a complex theme whilst considering various aspects. They also learn how to combine independent functions in a system.  The students become the ability to gain independently knowledge and transfer it also to new problem solving.
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	
Assignment for the Following Curricula	Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Hrs/wk 3 CP 5 Workload in Hours	5 Independent Study Time 108, Study Time in Lecture 42 Dr. Christian Scharfetter DE
CP 5 Workload in Hours In Lecturer D Language D Cycle W	Independent Study Time 108, Study Time in Lecture 42  Dr. Christian Scharfetter  DE  WiSe  Introduction Construction Aspects of a Steam Turbine Energy Conversion in a Steam Turbine Construction Types of Steam Turbines Behaviour of Steam Turbines Sealing Systems for Steam Turbines Axial Thrust Regulation of Steam Turbines Stiffness Calculation of the Blades Blade and Rotor Oscillations Fundamentals of a Safe Steam Turbine Operation Application in Conventional and Renewable Power Stations
Workload in Hours In Lecturer Description   Language Description   Cycle V	Independent Study Time 108, Study Time in Lecture 42  Dr. Christian Scharfetter  DE  WiSe  Introduction Construction Aspects of a Steam Turbine Energy Conversion in a Steam Turbine Construction Types of Steam Turbines Behaviour of Steam Turbines Sealing Systems for Steam Turbines Axial Thrust Regulation of Steam Turbines Stiffness Calculation of the Blades Blade and Rotor Oscillations Fundamentals of a Safe Steam Turbine Operation Application in Conventional and Renewable Power Stations
Lecturer D Language D Cycle V	Dr. Christian Scharfetter  DE  WiSe  Introduction Construction Aspects of a Steam Turbine Energy Conversion in a Steam Turbine Construction Types of Steam Turbines Behaviour of Steam Turbines Sealing Systems for Steam Turbines Axial Thrust Regulation of Steam Turbines Stiffness Calculation of the Blades Blade and Rotor Oscillations Fundamentals of a Safe Steam Turbine Operation Application in Conventional and Renewable Power Stations
Language Cycle V	<ul> <li>Introduction</li> <li>Construction Aspects of a Steam Turbine</li> <li>Energy Conversion in a Steam Turbine</li> <li>Construction Types of Steam Turbines</li> <li>Behaviour of Steam Turbines</li> <li>Sealing Systems for Steam Turbines</li> <li>Axial Thrust</li> <li>Regulation of Steam Turbines</li> <li>Stiffness Calculation of the Blades</li> <li>Blade and Rotor Oscillations</li> <li>Fundamentals of a Safe Steam Turbine Operation</li> <li>Application in Conventional and Renewable Power Stations</li> </ul>
Cycle V	<ul> <li>Introduction</li> <li>Construction Aspects of a Steam Turbine</li> <li>Energy Conversion in a Steam Turbine</li> <li>Construction Types of Steam Turbines</li> <li>Behaviour of Steam Turbines</li> <li>Sealing Systems for Steam Turbines</li> <li>Axial Thrust</li> <li>Regulation of Steam Turbines</li> <li>Stiffness Calculation of the Blades</li> <li>Blade and Rotor Oscillations</li> <li>Fundamentals of a Safe Steam Turbine Operation</li> <li>Application in Conventional and Renewable Power Stations</li> </ul>
Cycle V	<ul> <li>Introduction</li> <li>Construction Aspects of a Steam Turbine</li> <li>Energy Conversion in a Steam Turbine</li> <li>Construction Types of Steam Turbines</li> <li>Behaviour of Steam Turbines</li> <li>Sealing Systems for Steam Turbines</li> <li>Axial Thrust</li> <li>Regulation of Steam Turbines</li> <li>Stiffness Calculation of the Blades</li> <li>Blade and Rotor Oscillations</li> <li>Fundamentals of a Safe Steam Turbine Operation</li> <li>Application in Conventional and Renewable Power Stations</li> </ul>
Content	<ul> <li>Construction Aspects of a Steam Turbine</li> <li>Energy Conversion in a Steam Turbine</li> <li>Construction Types of Steam Turbines</li> <li>Behaviour of Steam Turbines</li> <li>Sealing Systems for Steam Turbines</li> <li>Axial Thrust</li> <li>Regulation of Steam Turbines</li> <li>Stiffness Calculation of the Blades</li> <li>Blade and Rotor Oscillations</li> <li>Fundamentals of a Safe Steam Turbine Operation</li> <li>Application in Conventional and Renewable Power Stations</li> </ul>
	<ul> <li>interfaces</li> <li>Conventional and regenerative power plant concepts, drive technology</li> <li>Analysis of the global energy supply market</li> <li>Applications in conventional and regenerative power plants</li> <li>Different power plant concepts and their influence on the steam turbine (engine and gas turbine power plants with waste heat utilization, geothermal energy, solar thermal energy, biomass, biogas, waste incineration).</li> <li>Classic combined heat and power generation as a combined product of the manufacturing industry</li> <li>Impact of change in the energy market, operating profiles</li> <li>Applications in drive technology</li> <li>Operating and maintenance concepts</li> <li>The lecture will be deepened by means of examples, tasks and two excursions</li> </ul>
Literature	<ul> <li>Traupel, W.: Thermische Turbomaschinen. Berlin u. a., Springer (TUB HH: Signatur MSI-105)</li> <li>Menny, K.: Strömungsmaschinen: hydraulische und thermische Kraft- und Arbeitsmaschinen. Ausgabe: 5. Wiesbaden, Teubner, 2006 (TUB HH: Signatur MSI-121)</li> <li>Bohl, W.: Aufbau und Wirkungsweise. Ausgabe 6. Würzburg, Vogel, 1994 (TUB HH: Signatur MSI-109)</li> <li>Bohl, W.: Berechnung und Konstruktion. Ausgabe 6. Aufl. Würzburg, Vogel, 1999 (TUB HH: Signatur MSI-110)</li> </ul>

Course L1287: Steam turbines in energy, environmental and Power Train Engineering		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Christian Scharfetter	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0742	2: Thermal Energy Systems			
Courses				
<b>Title</b> Thermal Engergy Systo	ems (L0023)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 5
Thermal Engergy Syste	ems (L0024)	Recitation (large)	Section 1	1
Module Responsible	Prof. Gerhard Schmitz			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dy	namics, Heat <sup>-</sup>	Transfer	
Educational Objectives	After taking part successfully, students h	ave reached t	the following learn	ing results
Professional Competence				
Knowledge	Students know the different energy con efficiency and annual efficiency. They had transfer, especially in regard to buildings with German energy saving code and of differ different heating systems in the control such heating systems. They are a transient temperatures in a furnace. The formations in the flames of small burne the atmosphere. They are able to moriented languages.	ave increased as and mobile as ther technical domestic and able to model ney have the rs and how t	knowledge in head applications. They relevant rules. The d industrial area a furnace and to dead basic knowledge o conduct the flu	at and mass are familian hey know to and how to calculate the of emission e gases into
Skills	Students are able to calculate the heatin to choose the suitable components. The and have the ability to perform simple p can write Modelica programs and can They are able to perform scientific work	ey are able to lanning tasks, transfer resea	calculate a pipe regarding solar e arch knowledge ir	line network energy. They nto practice
Personal Competence				
Social Competence	The students are able to discuss in small	groups and d	evelop an approa	ch.
Autonomy	Students are able to define independ existing knowledge as well as to find way			
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 5	6	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
	Bioprocess Engineering: Specialisation A Compulsory Energy and Environmental Engineering: Compulsory			_

Energy Systems: Specialisation Energy Systems: Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory
Product Development, Materials and Production: Core qualification: Elective
Compulsory
Renewable Energies: Core qualification: Compulsory
Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective
Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective
Compulsory
 Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0023: Thermal Engergy Systems			
Typ Lecture			
Hrs/wk	3		
СР	5		
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42		
Lecturer	Prof. Gerhard Schmitz		
Language	DE		
Cycle	WiSe		
Content	<ol> <li>Introduction</li> <li>Fundamentals of Thermal Engineering 2.1 Heat Conduction 2.2 Convection 2.3 Radiation 2.4 Heat transition 2.5 Combustion parameters 2.6 Electrical heating 2.7 Water vapor transport</li> <li>Heating Systems 3.1 Warm water heating systems 3.2 Warm water supply 3.3 piping calculation 3.4 boilers, heat pumps, solar collectors 3.5 Air heating systems 3.6 radiative heating systems</li> <li>Thermal traetment systems 4.1 Industrial furnaces 4.2 Melting furnaces 4.3 Drying plants 4.4 Emission control 4.5 Chimney calculation 4.6 Energy measuring</li> <li>Laws and standards 5.1 Buildings 5.2 Industrial plants</li> </ol>		
Literature	<ul> <li>Schmitz, G.: Klimaanlagen, Skript zur Vorlesung</li> <li>VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013</li> <li>Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009</li> <li>Recknagel, H.; Sprenger, E.; Schrammek, ER.: Taschenbuch für Heizungund Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013</li> </ul>		

Course L0024: Thermal Engergy Systems		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Gerhard Schmitz	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0508: Fluid Mechanics and Ocean Energy					
Courses					
<b>Title</b> Energy from the Ocear Fluid Mechanics II (L00		ļ	Typ Lecture	Hrs/wk 2 2	<b>CP</b> 2
		ı	Lecture		4
Admission Requirements	None				
	Technische Thermodynamik I-II Wärme- und Stoffübertragung				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	The students are able to describe different applications of fluid mechanics for the field of Renewable Energies. They are able to use the fundamentals of fluid mechanics for calculations of certain engineering problems in the field of ocean energy. The students are able to estimate if a problem can be solved with an analytical solution and what kind of alternative possibilities are available (e.g. self-similarity, empirical solutions, numerical methods).				
Skills	Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are able to formulate momentum and mass balances to optimize the hydrodynamics of technical processes. They are able to transform a verbal formulated message into an abstract formal procedure.				
Personal Competence					
Social Competence	The students are able t	le to solve a proble			
Autonomy	Students are able to define independently tasks for problems related to fluid mechanics. They are able to work out the knowledge that is necessary to solve the problem by themselves on the basis of the existing knowledge from the lecture.				
Workload in Hours	Independent Study Tim	e 124, Study Time	in Lecture 56		
Credit points	6				
Course achievement	CompulsorBonus Yes 10 %	<b>Form</b> Group discussion	Descript	ion	
Examination	Written exam				
Examination duration and scale					
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Renewable Energies: Core qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				

Course L0002: Energy from the Ocean			
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Moustafa Abdel-Maksoud		
Language	DE		
Cycle	WiSe		
Content	<ol> <li>Introduction to ocean energy conversion</li> <li>Wave properties         <ul> <li>Linear wave theory</li> <li>Nonlinear wave theory</li> <li>Irregular waves</li> <li>Wave energy</li> <li>Refraction, reflection and diffraction of waves</li> </ul> </li> <li>Wave energy converters         <ul> <li>Overview of the different technologies</li> <li>Methods for design and calculation</li> </ul> </li> <li>Ocean current turbine</li> </ol>		
Literature	<ul> <li>Cruz, J., Ocean wave energy, Springer Series in Green Energy and Technology, UK, 2008.</li> <li>Brooke, J., Wave energy conversion, Elsevier, 2003.</li> <li>McCormick, M.E., Ocean wave energy conversion, Courier Dover Publications, USA, 2013.</li> <li>Falnes, J., Ocean waves and oscillating systems, Cambridge University Press, UK, 2002.</li> <li>Charlier, R. H., Charles, W. F., Ocean energy. Tide and tidal Power. Berlin, Heidelberg, 2009.</li> <li>Clauss, G. F., Lehmann, E., Östergaard, C., Offshore Structures. Volume 1, Conceptual Design. Springer-Verlag, Berlin 1992</li> </ul>		

Course L0001: Fluid Mechanics II				
Тур	Lecture			
Hrs/wk	2			
СР	4			
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28			
Lecturer	Prof. Michael Schlüter			
Language	DE			
Cycle	WiSe			
Content	<ul> <li>Differential equations for momentum-, heat and mass transfer</li> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> <li>Coupling of momentum and heat transfer - Thermal Process Engineering</li> <li>Rheology - Bioprocess Engineering</li> <li>Coupling of momentum- and mass transfer - Reactive mixing, Chemical Process Engineering</li> <li>Flow threw porous structures - heterogeneous catalysis</li> <li>Pumps and turbines - Energy- and Environmental Process Engineering</li> <li>Wind- and Wave-Turbines - Renewable Energy</li> <li>Introduction into Computational Fluid Dynamics</li> </ul>			
Literature	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verla Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion Frankfurt: Sauerländer 1972.</li> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömunge von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994.</li> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und d mathematische Modellierung von Strömungen. Springer Verlag, Berlin Heidelberg, New York, 2006.</li> <li>Herwig, H.: Strömungsmechanik: Einführung in die Physik von technische Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden 2008.</li> <li>Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007.</li> <li>Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichunge Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlag GmbH, Wiesbaden, 2009.</li> <li>Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York 2007.</li> <li>Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementar Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin Heidelberg, 2008.</li> <li>Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.</li> <li>van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanfor California, 1882.</li> </ol>			

Courses Title				Тур		Hrs/wk	СР
Aircraft Systems I (L0735)				Lecture		3	4
Aircraft Systems I (L07)	39)			Recitation (large)	Section	<sup>n</sup> 2	2
Module Responsible	Prof. F	Frank Thielecke					
Admission Requirements	None						
Recommended Previous Knowledge	•	knowledge in:  Mathematics  Mechanics  Thermodynamics  Electrical Engineeri  Hydraulics  Control Systems	ing				
Educational Objectives	After	taking part successf	ully, students h	ave reached	the follo	wing learn	ing results
Professional Competence	Stude	nts are able to:					
Knowledge	Describe essential components and design points of hydraulic, electrical an high-lift systems     Cive an evention of the functionality of air conditioning systems.						
Skills	•	nts are able to: Design hydraulic a Design high-lift sys Analyze the thermo	tems of aircraft	S			5
Personal Competence	Stude	nts are able to:					
Social Competence	•	Perform system de	sign in groups a	and present	and discu	ıss results	
Autonomy	Students are able to:  • Reflect the contents of lectures autonomously						
Workload in Hours	Indep	endent Study Time	110, Study Time	e in Lecture	70		
Credit points	6						
Course achievement	None						
		en exam					

duration and scale	
Assignment for the Following Curricula	Compulsory

Course L0735: Airc	raft Systems I
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	WiSe
Content	<ul> <li>Hydraulic Energy Systems (Fluids; pressure loss in valves and pipes; components of hydraulic systems like pumps, valves, etc.; pressure/flow characteristics; actuators; tanks; power and heat balances; emergency power)</li> <li>Electric Energy Systems (Generators; constant-speed-drives; DC and AC converters; electrical power distribution; bus systems; monitoring; load analysis)</li> <li>High Lift Systems (Principles; investigation of loads and system actuation power; principles and sizing of actuation and positioning systems; safety requirements and devices)</li> <li>Environmental Control Systems (Thermodynamic analysis; expansion and compression cooling systems; control strategies; cabin pressure control systems)</li> </ul>
Literature	<ul> <li>Moir, Seabridge: Aircraft Systems</li> <li>Green: Aircraft Hydraulic Systems</li> <li>Torenbek: Synthesis of Subsonic Airplane Design</li> <li>SAE1991: ARP; Air Conditioning Systems for Subsonic Airplanes</li> </ul>

Course L0739: Aircraft Systems I		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Frank Thielecke	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0812	2: Aircraft Design				
Courses					
Title	or of Transport Alexandry (LOCO)	Тур	Hrs/wk	СР	
Aircraft Design I (Design of Transport Aircraft) (L0820) Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV) (L0844)		Lecture Lecture	2	2	
•	ceptual Design of Rotorcraft, special	Recitation (large)	Section 1	1	
Aircraft Design I (L083	4)	Recitation (large)	Section 1	1	
Module Responsible	Prof. Volker Gollnick				
Admission Requirements	None				
Recommended Previous Knowledge	<ul> <li>Vordiplom Mech. Eng.</li> </ul>				
Educational Objectives	After taking part successfully, students	have reached	the following learr	ing results	
Professional Competence					
Knowledge	<ol> <li>Principle understanding of integrated aircraft design</li> <li>Understanding of the interactions and contributions of the various disciplines</li> <li>Impact of the relevant design parameter on the aircraft design</li> <li>Introduction of the principle design methods</li> </ol>				
	Understanding and application of desig	n and calculati	ion methods		
Skills	Understanding of interdisciplinary and	Understanding of interdisciplinary and integrative interdependencies			
Personal Competence					
Social Competence	Working in interdisciplinary teams  Communication				
Autonomy	Organization of workflows and -strategi	ies			
	Independent Study Time 96, Study Tim		1		
Credit points					
Course achievement	None				
Examination	Written exam				
Examination duration and scale					
the Following	Aircraft Systems Engineering: Core qua International Management and Engin Elective Compulsory Product Development, Materials Development: Elective Compulsory Theoretical Mechanical Engineering: Compulsory Theoretical Mechanical Engineering: States	eering: Special and Product	alisation II. Aviationion: Specialisation	on Product	

Course L0820: Airc	raft Design I (Design of Transport Aircraft)
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	<ol> <li>Introduction into the aircraft design process</li> <li>Introduction/process of aircraft design/various aircraft configurations</li> <li>Requirements and design objectives, main design parameter (u.a. payload-range-diagramme)</li> <li>Statistical methods in overall aircraft design/data base methods</li> <li>Principles of aircraft performance design (stability, V-n-diagramme)</li> <li>Principles of aerodynamic aircraft design (polar, geometry, 2D/3D aerodynamics)</li> <li>Principles of structural fuselage and wing design (mass analysis, beam/tube models, geometry)</li> <li>Principles of engine design and integration</li> <li>Cruise design</li> <li>Design of runway and landing field length</li> <li>Cabin design (fuselage dimensioning, cabin interior, loading systems)</li> <li>System- and equipment aspects</li> <li>Design variations and operating cost calculation</li> </ol>
Literature	J. Roskam: "Airplane Design"  D.P. Raymer: "Aircraft Design - A Conceptual Approach"  J.P. Fielding: "Intorduction to Aircraft Design"  Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"

Course L0844: Airc UAV)	raft Design II (Conceptual Design of Rotorcraft, special operations aircraft,
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Volker Gollnick, Dr. Bernd Liebhardt
Language	DE/EN
Cycle	SoSe
Content	Take Off and landing  Loads on Aircraft  Operation Cost  Principles of Rotorcraft Design  Principles of high performance aircraft design  Principles of special operations aircraft design  Principles of Unmanned Air Systems design
Literature	Gareth Padfield: Helicopter Flight Dynamics Raymond Prouty: Helicopter Performance Stability and Control Klaus Hünecke: Das Kampfflugzeug von Heute

Course L0847: Airc	raft Design II (Conceptual Design of Rotorcraft, special operations aircraft,
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Volker Gollnick, Dr. Bernd Liebhardt
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0834: Aircraft Design I			
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	1		
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Volker Gollnick		
Language	DE		
Cycle	WiSe		
Content	Training in applying MatLab  Application of design methods for civil aircraft concerning:  Fuselage and Cabin sizing and design  Calculation of aircraft masses  Aerodynamic and geometric wing design  TakeOff, landing cruise performance calculation  Manoevre and gust load calculation		
Literature	J. Roskam: "Airplane Design"  D.P. Raymer: "Aircraft Design - A Conceptual Approach"  J.P. Fielding: "Intorduction to Aircraft Design"  Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"		

Module M1149	9: Marine Power Engineerin	g			
Courses					
<b>Title</b> Electrical Installation o	n Ships (L1531)	<b>Typ</b> Lecture Recitation	Section	Hrs/wk 2	<b>CP</b> 2
Electrical Installation o	n Ships (L1532)	(large)	Section	1	1
Marine Engineering (L	1569)	Lecture Recitation	Soction	2	2
Marine Engineering (L1	L570)	(large)	Section	1	1
Module Responsible	Prof. Christopher Friedrich Wirz				
Admission Requirements	None				
Recommended Previous Knowledge					
Educational Objectives	After taking part successfully, students	have reached	the follow	wing learn	ing results
Professional Competence					
Knowledge	The students are able to describe the state-of-the-art regarding the wide range of propulsion components on ships and apply their knowledge. They further know how to analyze and optimize the interaction of the components of the propulsion system and how to describe complex correlations with the specific technical terms in German and English. The students are able to name the operating behaviour of consumers, describe special requirements on the design of supply networks and to the electrical equipment in isolated networks, as e.g. onboard ships, offshore units, factories and emergency power supply systems, explain power generation and distribution in isolated grids, wave generator systems on ships, and name requirements for network protection, selectivity and operational monitoring.				
Skills	The students are skilled to employ reciprocating machinery, their selection further able to assess, analyse and solution propulsion and auxiliary plants and to have the skills to describe complex concluded disciplines. Students are able to and design electrical propulsion systems	on and operat lve technical a o design prop rrelations and o calculate sho	ion on b and opera ulsion sy I bring th	oard ship ational pro stems. The nem into c	s. They are oblems with he students context with
Personal Competence Social Competence	The students are able to communicate a in the shipbuilding and component supp		in a prot	fessional e	environment
Autonomy	The widespread scope of gained kn situations in their future profession inde				to handle
Workload in Hours	Independent Study Time 96, Study Time	e in Lecture 84	ļ		
Credit points	6				
Course achievement	None				
Examination	Written exam				

Examination duration and scale	90 minutes plus 20 minutes oral exam
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1531: Elec	trical Installation on Ships
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	<ul> <li>performance in service of electrical consumers.</li> <li>special requirements for power supply systems and for electrical equipment in isolated systems/networks e. g. aboard ships, offshore installations, factory systems and emergency power supply systems.</li> <li>power generation and distribution in isolated networks, shaft generators for ships</li> <li>calculation of short circuits and behaviour of switching devices</li> <li>protective devices, selectivity monitoring</li> <li>electrical Propulsion plants for ships</li> </ul>
Literature	H. Meier-Peter, F. Bernhardt u. a.: Handbuch der Schiffsbetriebstechnik, Seehafen Verlag (engl. Version: "Compendium Marine Engineering") Gleß, Thamm: Schiffselektrotechnik, VEB Verlag Technik Berlin

Course L1532: Electrical Installation on Ships	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1569: Marine Engineering	
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	WiSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1570: Marine Engineering	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M115	5: Aircraft Cabin Systems			
Courses				
<b>Title</b> Aircraft Cabin Systems Aircraft Cabin Systems		Typ Lecture Recitation	Hrs/wk 3 Section 1	<b>CP</b> 4
Module Responsible	Prof. Ralf God	(large)		
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in:  • Mathematics  • Mechanics  • Thermodynamics  • Electrical Engineering  • Control Systems			
Educational Objectives	After taking part successfully, students h	ave reached t	he following learn	ing results
Professional Competence				
Knowledge	Students are able to:  • describe cabin operations, equipment in the cabin and cabin Systems  • explain the functional and non-functional requirements for cabin Systems  • elucidate the necessity of cabin operating systems and emergency Systems  • assess the challenges human factors integration in a cabin environment			
Skills	Students are able to:  • design a cabin layout for a given business model of an Airline  • design cabin systems for safe operations  • design emergency systems for safe man-machine interaction  • solve comfort needs and entertainment requirements in the cabin			
Personal Competence				
Social Competence	Students are able to: • understand existing system solutions a	nd discuss the	eir ideas with expo	erts
Autonomy	Students are able to: • Reflect the contents of lectures and ex	pert presentat	ions self-depende	ent
<b>Workload in Hours</b>	Independent Study Time 124, Study Time	e in Lecture 50	5	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 Minutes			
Assignment for	Electrical Engineering: Specialisation ( Elective Compulsory Energy Systems: Specialisation Energy S Aircraft Systems Engineering: Core qualif International Management and Engineer Elective Compulsory Product Development, Materials as Development: Elective Compulsory	ystems: Electi fication: Comp	ve Compulsory Julsory Julsation II. Aviatio	on Systems:

the	Following	F
	Curricula	C

Product Development, Materials and Production: Specialisation Production: Elective Compulsory

Product Development, Materials and Production: Specialisation Materials: Elective Compulsory

Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1545: Airc	raft Cabin Systems
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about aircraft cabin systems and cabin operations. A basic understanding of technological and systems engineering effort to maintain an artificial but comfortable and safe travel and working environment at cruising altitude is to be achieved.  The course provides a comprehensive overview of current technology and cabin systems in modern passenger aircraft. The Fulfillment of requirements for the cabin as the central system of work are covered on the basis of the topics comfort, ergonomics, human factors, operational processes, maintenance and energy supply:  • Materials used in the cabin • Ergonomics and human factors • Cabin interior and non-electrical systems • Cabin electrical systems and lights • Cabin electronics, communication-, information- and IFE-systems • Cabin and passenger process chains • RFID Aircraft Parts Marking • Energy sources and energy conversion
Literature	<ul> <li>Skript zur Vorlesung</li> <li>Jenkinson, L.R., Simpkin, P., Rhodes, D.: Civil Jet Aircraft Design. London: Arnold, 1999</li> <li>Rossow, CC., Wolf, K., Horst, P. (Hrsg.): Handbuch der Luftfahrzeugtechnik. Carl Hanser Verlag, 2014</li> <li>Moir, I., Seabridge, A.: Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, Wiley 2008</li> <li>Davies, M.: The standard handbook for aeronautical and astronautical engineers. McGraw-Hill, 2003</li> <li>Kompendium der Flugmedizin. Verbesserte und ergänzte Neuauflage, Nachdruck April 2006. Fürstenfeldbruck, 2006</li> <li>Campbell, F.C.: Manufacturing Technology for Aerospace Structural Materials. Elsevier Ltd., 2006</li> </ul>

Course L1546: Aircraft Cabin Systems	
Тур	Recitation Section (large)
Hrs/wk	1
СР	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1157	7: Marine Auxiliaries				
Courses					
Courses		<b>T</b>		11 /1-	
<b>Title</b> Electrical Installation of	on Ships (L1531)	<b>Typ</b> Lecture		Hrs/wk 2	<b>CP</b> 2
Electrical Installation o		Recitation	Section	_	1
Auxiliary Systems on E	·	(large) Lecture		2	2
Auxiliary Systems on E	•	Recitation	Section	_	1
Auxiliary Systems on E	Source of Ships (E1230)	(large)		1	
Module Responsible	I Prot ( nristonnar Friadrich Wirz				
Admission Requirements	None				
Recommended Previous Knowledge					
Educational Objectives		idents have reached	the follow	ving learn	ing results
Professional Competence					
	The students are able to				
Knowledge	<ul> <li>name the operating behaviour of consumers,</li> <li>describe special requirements on the design of supply networks and to the electrical equipment in isolated networks, as e.g. onboard ships, offshore units, factories and emergency power supply systems,</li> <li>explain power generation and distribution in isolated grids, wave generator systems on ships,</li> <li>name requirements for network protection, selectivity and operational monitoring,</li> <li>name the requirements regarding marine equipment and apply to product development, as well as</li> <li>describe operating procedures of equipment components of standard and specialized ships and derive requirements for product development.</li> </ul>				
Skills	<ul> <li>Students are able to</li> <li>calculate short-circuit currents,</li> <li>design electrical propulsion sys</li> <li>design additional machinery co</li> <li>to apply basic principles of hydi</li> </ul>	tems for ships mponents, as well as		ic system	<b>15</b> .
Personal Competence		dunes and to develo	p my ar a a .	ic system	
Social Competence	The students are able to commur in the shipbuilding and componer		in a prof	essional e	environment
Autonomy	The widespread scope of gain situations in their future profession				to handle
Workload in Hours	Independent Study Time 96, Stud	ly Time in Lecture 84			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
	İ				

Examination duration and scale	20 min
Assignment for the Following	Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L1531: Elec	trical Installation on Ships
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	<ul> <li>performance in service of electrical consumers.</li> <li>special requirements for power supply systems and for electrical equipment in isolated systems/networks e. g. aboard ships, offshore installations, factory systems and emergency power supply systems.</li> <li>power generation and distribution in isolated networks, shaft generators for ships</li> <li>calculation of short circuits and behaviour of switching devices</li> <li>protective devices, selectivity monitoring</li> <li>electrical Propulsion plants for ships</li> </ul>
Literature	H. Meier-Peter, F. Bernhardt u. a.: Handbuch der Schiffsbetriebstechnik, Seehafen Verlag (engl. Version: "Compendium Marine Engineering") Gleß, Thamm: Schiffselektrotechnik, VEB Verlag Technik Berlin

Course L1532: Electrical Installation on Ships	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1249: Auxiliary Systems on Board of Ships		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Christopher Friedrich Wirz	
Language	DE	
Cycle	SoSe	
Content	<ul> <li>Vorschriften zur Schiffsausrüstung</li> <li>Ausrüstungsanlagen auf Standard-Schiffen</li> <li>Ausrüstungsanlagen auf Spezial-Schiffen</li> <li>Grundlagen und Systemtechnik der Hydraulik</li> <li>Auslegung und Betrieb von Ausrüstungsanlagen</li> </ul>	
Literature	<ul> <li>H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik</li> <li>H. Watter: Hydraulik und Pneumatik</li> </ul>	

Course L1250: Auxiliary Systems on Board of Ships		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Christopher Friedrich Wirz	
Language	DE .	
Cycle	oSe	
Content		
	Siehe korrespondierende Vorlesung	
Literature		

Module M1177	7: Maritime Technolog	y and Mari	time Syst	ems	
Courses					
Title		Тур		Hrs/wk	СР
Analysis of Maritime Systems (L0068)		Lecture		2	2
Analysis of Maritime Sy	ystems (L0069)	Recitat (small)	ion Section	n 1	1
Introduction to Maritim	ne Technology (L0070)	Lecture	2	2	2
Introduction to Maritim	ne Technology (L1614)	Recitat (small)	ion Section	n 1	1
Module		(Smail)			
Responsible	Prof. Moustara Abdel-Maksoud				
Admission Requirements	None				
Recommended Previous Knowledge	Solid knowledge and competences in mechanics, fluid dynamics and analysis (series, periodic functions, continuity, differentiability, integration, multiple variables, ordinaray and partial differential equations, boundary value problems, initial conditions and eigenvalue problems).				
Educational Objectives	After taking part successfully, s	tudents have rea	ched the follo	wing learn	ing results
Professional Competence					
Knowledge	After successful completion of this class, students should have an overview about phenomena and methods in ocean engineering and the ability to apply and extend the methods presented.  In detail, the students should be able to  • describe the different aspects and topics in Maritime Technology,  • apply existing methods to problems in Maritime Technology,  • discuss limitations in present day approaches and perspectives in the future,  • Techniques for the analysis of offshore systems,				
Skills	<ul> <li>Modeling and evaluation of dynamic systems,</li> <li>System-oriented thinking, decomposition of complex systems.</li> </ul> The students learn the ability of apply and transfer existing methods and techniques on novel questions in maritime technologies. Furthermore, limits of the existing knowledge and future developments will be discussed.				
Personal					
Competence Social Competence	The processing of an exercise in a group of up to four students shall strengthen the communication and team-working skills and thus promote an important working				
Autonomy	The course contents are absorbed in an exercise work in a group and individually checked in a final exam in which a self-reflection of the learned is expected without tools.				
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84				
Credit points	6				
Course achievement	LNODE				
	Written exam				
Examination					

duration and	180 min
scale	
	Naval Architecture and Ocean Engineering: Core qualification: Compulsory
Assignment for	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
the Following	
Curricula	Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective
	Compulsory

Course L0068: Ana	lysis of Maritime Systems
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud, Dr. Alexander Mitzlaff
Language	DE
Cycle	SoSe
Content	<ol> <li>Hydrostatic analysis         <ul> <li>Buoyancy,</li> <li>Stability,</li> </ul> </li> <li>Hydrodynamic analysis         <ul> <li>Froude-Krylov force</li> <li>Morison's equation,</li> <li>Radiation and diffraction</li> <li>transparent/compact structures</li> </ul> </li> <li>Evaluation of offshore structures: Reliability techniques (security, reliability, disposability)         <ul> <li>Short-term statistics</li> <li>Long-term statistics and extreme events</li> </ul> </li> </ol>
Literature	<ul> <li>G. Clauss, E. Lehmann, C. Östergaard. Offshore Structures Volume I: Conceptual Design and Hydrodynamics. Springer Verlag Berlin, 1992</li> <li>E. V. Lewis (Editor), Principles of Naval Architecture ,SNAME, 1988</li> <li>Journal of Offshore Mechanics and Arctic Engineering</li> <li>Proceedings of International Conference on Offshore Mechanics and Arctic Engineering</li> <li>S. Chakrabarti (Ed.), Handbook of Offshore Engineering, Volumes 1-2, Elsevier, 2005</li> <li>S. K. Chakrabarti, Hydrodynamics of Offshore Structures, WIT Press, 2001</li> </ul>

Course L0069: Analysis of Maritime Systems		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Moustafa Abdel-Maksoud, Dr. Alexander Mitzlaff	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0070: Intr	oduction to Maritime Technology
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Sven Hoog
Language	DE
Cycle	WiSe
Content	<ol> <li>Introduction         <ul> <li>Ocean Engineering and Marine Research</li> <li>The potentials of the seas</li> <li>Industries and occupational structures</li> </ul> </li> <li>Coastal and offshore Environmental Conditions         <ul> <li>Physical and chemical properties of sea water and sea ice</li> <li>Flows, waves, wind, ice</li> <li>Biosphere</li> </ul> </li> <li>Response behavior of Technical Structures</li> <li>Maritime Systems and Technologies         <ul> <li>General Design and Installation of Offshore-Structures</li> <li>Geophysical and Geotechnical Aspects</li> <li>Fixed and Floating Platforms</li> <li>Mooring Systems, Risers, Pipelines</li> <li>Energy conversion: Wind, Waves, Tides</li> <li>Tides</li> <li>Energy conversion: Wind, Waves, Tides</li> <li>Tides</li> /ul></li></ol>
Literature	<ul> <li>Chakrabarti, S., Handbook of Offshore Engineering, vol. I/II, Elsevier 2005.</li> <li>Gerwick, B.C., Construction of Marine and Offshore Structures, CRC-Press 1999.</li> <li>Wagner, P., Meerestechnik, Ernst&amp;Sohn 1990.</li> <li>Clauss, G., Meerestechnische Konstruktionen, Springer 1988.</li> <li>Knauss, J.A., Introduction to Physical Oceanography, Waveland 2005.</li> <li>Wright, J. et al., Waves, Tides and Shallow-Water Processes, Butterworth 2006.</li> <li>Faltinsen, O.M., Sea Loads on Ships and Offshore Structures, Cambridge 1999.</li> </ul>

Course L1614: Introduction to Maritime Technology		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Sven Hoog	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1146	5: Ship Vibration				
Courses					
<b>Title</b> Ship Vibration (L1528)		<b>Typ</b> Lecture		Hrs/wk	<b>CP</b> 3
Ship Vibration (L1529)		Recitation (small)	Section	2	3
	Dr. Rüdiger Ulrich Franz von Bock und Po	olach			
Admission Requirements	None				
Recommended Previous Knowledge	Fundamentals of Chin Structural Design				
Educational Objectives	After taking part successfully, students h	nave reached t	the follo	wing learn	ing results
Professional Competence					
Knowledge	Students can reproduce the acceptance criteria for vibrations on ships; they can explain the methods for the calculation of natural frequencies and forced vibrations of cruetural components and the entire bull girder, they understand the effect of				
Skills	Students are capable to apply methods for the calculation of natural frequencies and exciting forces and resulting vibrations of ship structures including their assessment; they can model structures for the vibration analysis				
Personal Competence					
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.				
Autonomy	Students are able to detect vibration-prone components on ships, to model the structure, to select suitable calculation methods and to assess the results				
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Course achievement	None				
Examination	Written exam				
Examination duration and scale					
the Following	Energy Systems: Specialisation Marine Engineering: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Compulsory Ship and Offshore Technology: Core qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				

Course L1528: Ship	Vibration
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach
Language	EN
Cycle	WiSe
Content	<ol> <li>Introduction; assessment of vibrations</li> <li>Basic equations</li> <li>Beams with discrete / distributed masses</li> <li>Complex beam systems</li> <li>Vibration of plates and Grillages</li> <li>Deformation method / practical hints / measurements</li> <li>Hydrodynamic masses</li> <li>Spectral method</li> <li>Hydrodynamic masses acc. to Lewis</li> <li>Damping</li> <li>Shaft systems</li> <li>Propeller excitation</li> <li>Engines</li> </ol>
Literature	Siehe Vorlesungsskript

Course L1529: Ship	) Vibration
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach
Language	EN
Cycle	WiSe
Content	<ol> <li>Introduction; assessment of vibrations</li> <li>Basic equations</li> <li>Beams with discrete / distributed masses</li> <li>Complex beam systems</li> <li>Vibration of plates and Grillages</li> <li>Deformation method / practical hints / measurements</li> <li>Hydrodynamic masses</li> <li>Spectral method</li> <li>Hydrodynamic masses acc. to Lewis</li> <li>Damping</li> <li>Shaft systems</li> <li>Propeller excitation</li> <li>Engines</li> </ol>
Literature	Siehe Vorlesungsskript

Courses						
Title Industrial Process Auto	emation (LO344)		<b>Typ</b> Lecture		Hrs/wk	<b>CP</b>
Industrial Process Auto			Recitation (small)	Section	<del>-</del>	3
Module			(Siliali)			
Responsible		eter				
Admission Requirements						
Previous	mathematics and optimization methods principles of automata principles of algorithms and data structures programming skills					
Educational Objectives	LATTOR FAKING NART SHECK	essfully, students h	ave reached	the follo	wing learn	ing results
Professional Competence						
Knowledge	The students can evaluate and assess discrete event systems. They can evaluate properties of processes and explain methods for process analysis. The students can compare methods for process modelling and select an appropriate method fo actual problems. They can discuss scheduling methods in the context of actual problems and give a detailed explanation of advantages and disadvantages of different programming methods. The students can relate process automation to methods from robotics and sensor systems as well as to recent topics like 'cyberphysical systems' and 'industry 4.0'.					
Skills	The students are all accordingly. This invo	olves taking into a	ccount optin	nal sche	and eva duling, un	aluate the derstandir
Personal Competence	! 					
Social Competence	The students work in t	teams to solve prob	olems.			
Autonomy	The students can reflect their knowledge and document the results of their work.					
Workload in Hours	Independent Study Tir	me 124, Study Tim	e in Lecture 5	56		
Credit points						
Course achievement	CompulsorBonus No 10 %	Form Excercises		Descript	ion	
Examination	Written exam					
Examination duration and scale	90 minutes					
	Bioprocess Engineerin Compulsory Chemical and Bioproc Elective Compulsory					

the Following	Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory
Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory
	'
	Mechanical Engineering and Management: Specialisation Mechatronics: Elective
	Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory
	Process Engineering: Specialisation Chemical Process Engineering: Elective
	Compulsory
	Process Engineering: Specialisation Process Engineering: Elective Compulsory
	Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0344: Industrial Process Automation		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>foundations of problem solving and system modeling, discrete event systems</li> <li>properties of processes, modeling using automata and Petri-nets</li> <li>design considerations for processes (mutex, deadlock avoidance, liveness)</li> <li>optimal scheduling for processes</li> <li>optimal decisions when planning manufacturing systems, decisions under uncertainty</li> <li>software design and software architectures for automation, PLCs</li> </ul>	
Literature	J. Lunze: "Automatisierungstechnik", Oldenbourg Verlag, 2012 Reisig: Petrinetze: Modellierungstechnik, Analysemethoden, Fallstudien; Vieweg+Teubner 2010 Hrúz, Zhou: Modeling and Control of Discrete-event Dynamic Systems; Springer 2007 Li, Zhou: Deadlock Resolution in Automated Manufacturing Systems, Springer 2009 Pinedo: Planning and Scheduling in Manufacturing and Services, Springer 2009	

Course L0345: Industrial Process Automation	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Courses					
<b>Title</b> Hierarchical Algorithm	s (L058	5)	<b>Typ</b> Lecture	Hrs/wl	<b>CP</b> 3
Hierarchical Algorithm	s (L058	6)	Recitation (small)	Section 2	3
Module Responsible	Prof. S	Sabine Le Borne	(		
Admission Requirements	None				
Recommended Previous Knowledge		Mathematics I, II, III for Eng & Linear Algebra I + II as we Programming experience in	ell as Analysis III fo		
Educational Objectives	After t	taking part successfully, stud	ents have reached	the following lea	rning results
Professional Competence					
Knowledge	•	nts are able to  name representatives of hie explain construction technic discuss aspects regarding algorithms.  nts are able to	ues for hierarchica	al algorithms,	
Skills	•	implement the hierarchical analyse the storage and cor adapt algorithms to prob develop problem adapted vi	nputational comple em settings of v	exities of the algo	
Personal Competence					
Social Competence	•	nts are able to  work together in heterog different study programs a foundations and support e implementation of algorithm	and background k ach other with p	nowledge), expla	in theoretic
Autonomy	•	nts are capable  to assess whether the sup better solved individually or to work on complex problem to assess their individual p seek help.	in a team, ns over an extende	d period of time,	
Workload in Hours	Indep	endent Study Time 124, Stud	y Time in Lecture	56	
Credit points					
Course achievement	INIANA				
Examination	!	xam			
Examination duration and scale	20 min				

	Computer Science: Specialisation III. Mathematics: Elective Compulsory Mathematical Modelling in Engineering: Theory, Numerics, Applications: Specialisation II. Modelling and Simulation of Complex Systems (TUHH): Elective Compulsory
Assignment for	Technomathematics: Specialisation I. Mathematics: Elective Compulsory
tne Following	Theoretical Mechanical Engineering: Technical Complementary Course: Flective I
Curricula	Compulsory
	Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science:
	Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective
	Compulsory

Course L0585: Hierarchical Algorithms		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Sabine Le Borne	
Language	DE/EN	
Cycle	WiSe	
Content	<ul> <li>Low rank matrices</li> <li>Separable expansions</li> <li>Hierarchical matrix partitions</li> <li>Hierarchical matrices</li> <li>Formatted matrix operations</li> <li>Applications</li> <li>Additional topics (e.g. H2 matrices, matrix functions, tensor products)</li> </ul>	
Literature	W. Hackbusch: Hierarchische Matrizen: Algorithmen und Analysis	

Course L0586: Hierarchical Algorithms	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0550	): Digital Image Analy	rsis		
Courses				
<b>Title</b> Digital Image Analysis	(10126)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 6
		Lecture	4	0
Responsible	Prof. Rolf-Rainer Grigat			
Admission Requirements	None			
Recommended Previous Knowledge	theory, interpolation and de systems), linear algebra (Eige statistics (expectation values, i	System theory of one-dimensional signals (convolution and correlation, sampling theory, interpolation and decimation, Fourier transform, linear time-invariant systems), linear algebra (Eigenvalue decomposition, SVD), basic stochastics and statistics (expectation values, influence of sample size, correlation and covariance, normal distribution and its parameters), basics of Matlab, basics in optics		
Educational Objectives	After taking part successfully, s	tudents have reached the follo	wing learn	ing results
Professional Competence				
Knowledge	<ul><li>in their context</li><li>Interpret effects of the</li></ul>	nsorics	imaging s	_
		methods and procedures of the evelop and implement creative the through the characters are the characters are the characters are considered to the characters are considered to the characters are considered to the characters are considered to the characters are	solutions.	
Skills	design of image processing and	d image analysis systems.	·	
	Students are able to assess decision-making areas.	different Solution approache	s in muiti	aimensionai
	Students can undertake a proto	otypical analysis of processes in	n Matlab.	
Personal Competence				
-	k.A.			
Social Competence				
Autonomy	Students can solve image analy	ysis tasks independently using	the relevai	nt literature.
Workload in Hours	Independent Study Time 124, S	Study Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
				-

Examination duration and scale	60 Minutes, Content of Lecture and materials in StudIP
the Following	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Software and Signal Processing: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

Course L012C: Dist	tal Imana Analysis	
Course L0126: Digi		
	Lecture	
Hrs/wk		
СР	6	
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Rolf-Rainer Grigat	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>features (filters, edge detection, morphology, invariance, statistical features, texture)</li> <li>optical flow ( variational methods, quadratic optimization, Euler-Lagrange equations)</li> <li>segmentation (distance, region growing, cluster analysis, active contours, level sets, energy minimization and graph cuts)</li> <li>registration (distance and similarity, variational calculus, iterative closest points)</li> </ul>	
Literature	Bredies/Lorenz, Mathematische Bildverarbeitung, Vieweg, 2011 Wedel/Cremers, Stereo Scene Flow for 3D Motion Analysis, Springer 2011 Handels, Medizinische Bildverarbeitung, Vieweg, 2000 Pratt, Digital Image Processing, Wiley, 2001 Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1989	

Module M088	1: Mathematical Image Pi	ocessing		
Courses				
<b>Title</b> Mathematical Image Properties of the Mat	-	<b>Typ</b> Lecture Recitation (small)	Hrs/wk 3 Section 1	<b>CP</b> 4 2
Module Responsible	IPINI WAIKN I INNNET	(33)		
Admission Requirements	1			
Recommended Previous Knowledge	Analysis: partial derivatives, g     Linear Algebra: pigenvalues li			tem
Educational Objectives	After taking part successfully, studer	nts have reached t	he following learn	ing results
Professional Competence				
Knowledge	characterize and compare diff	of image processin mentation and reg	gistration	
Skills	Students are able to  implement and apply element explain and apply modern me			
Personal Competence				
Social Competence	Students are able to work together in from different study programs a theoretical foundations.			
Autonomy	<ul> <li>Students are capable of check their own. They can specify o help in solving them.</li> <li>Students have developed suff periods in a goal-oriented man</li> </ul>	pen questions pre icient persistence	cisely and know we to be able to wo	vhere to get
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 56	5	
Credit points	6			
Course achievement	None			
Examination	1			
Examination duration and scale	20 min			
Assignment for	Bioprocess Engineering: Specialisation Compulsory Computer Science: Specialisation III. Computational Science and Engine Compulsory Mechatronics: Technical Complement Mechatronics: Specialisation Intellige	Mathematics: Electering: Specialisati	ctive Compulsory on III. Mathemat	ics: Elective

	Mechatronics: Specialisation System Design: Elective Compulsory
Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science:
	Elective Compulsory
	Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0991: Mathematical Image Processing	
Тур	Lecture
Hrs/wk	3
СР	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	WiSe
Content	<ul> <li>basic methods of image processing</li> <li>smoothing filters</li> <li>the diffusion / heat equation</li> <li>variational formulations in image processing</li> <li>edge detection</li> <li>de-convolution</li> <li>inpainting</li> <li>image segmentation</li> <li>image registration</li> </ul>
Literature	Bredies/Lorenz: Mathematische Bildverarbeitung

Course L0992: Mathematical Image Processing		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Marko Lindner	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0586	6: Efficient Algorithms				
Courses					
<b>Title</b> Efficient Algorithms (LC) Efficient Algorithms (L1)		<b>Typ</b> Lecture Recitation (small)		Hrs/wk	<b>CP</b> 3
	Prof. Siegfried Rump				
Admission Requirements	None				
Previous	Programming in Matlab and/				
	Basic knowledge in discrete				
	After taking part successfully, students	s have reached	the follow	ing learn	ing results
Professional Competence					
Knowledge	The students are able to explain the basic theory and methods of network algorithms and in particular their data structures. They are able to analyze the computational behavior and computing time of linear programming algorithms as well network algorithms. Moreover the students can distinguish between efficiently solvable and NP-hard problems.				
Skills	The students are able to analyze complex tasks and can determine possibilities to transform them into networking algorithms. In particular they can efficiently implement basic algorithms and data structures of LP- and network algorithms and identify possible weaknesses. They are able to distinguish between different efficient data structures and are able to use them appropriately.				
Personal Competence					
	The students have the skil		-		
Autonomy	The students are able to retrieve necessary informations from the given literature and to combine them with the topics of the lecture. Throughout the lecture they can check their abilities and knowledge on the basis of given exercises and test questions providing an aid to optimize their learning process.				
	Independent Study Time 124, Study T	ime in Lecture 5	6		
Credit points					
Course achievement	None				_
Examination	,				
Examination duration and					

scale	
Assignment for the Following Curricula	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

Course L0120: Effic	cient Algorithms
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
	Prof. Siegfried Rump
Language	
Cycle	
	- Linear Programming
	- Data structures
	- Leftist heaps
Content	- Minimum spanning tree
	- Shortest path
	- Maximum flow
	- NP-hard problems via max-cut
Literature	R. E. Tarjan: Data Structures and Network Algorithms. CBMS 44, Society for Industrial and Applied Mathematics, Philadelphia, PA, 1983.
	Wesley, 2011 http://algs4.cs.princeton.edu/home/
	V. Chvátal, ``Linear Programming'', Freeman, New York, 1983.

Course L1207: Efficient Algorithms		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Siegfried Rump	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1020	0: Numerics of Partial Di	fferential Eq	uations		
Courses					
	ferential Equations (L1247) ferential Equations (L1248)	<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3	
Module Responsible	Prof. Daniel Ruprecht	(Sinan)			
Admission Requirements					
Recommended Previous Knowledge	II for Technomathematicians  • Numerical mathematics 1	_		r Algebra I +	
Educational Objectives	After taking part successfully, stude	ents have reached	the following learr	ning results	
Professional Competence					
Knowledge	<ul> <li>Students can classify partial differential equations according to the three basic types.</li> <li>For each type, students know suitable numerical approaches.</li> <li>Students know the theoretical convergence results for these approaches.</li> </ul>				
	Students are capable to formulate solution strategies for given problems involving partial differential equations, to comment on theoretical properties concerning convergence and to implement and test these methods in practice.				
Personal Competence					
Social Competence	Students are able to work together				
Autonomy	<ul> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>				
<b>Workload in Hours</b>	Independent Study Time 124, Stud	y Time in Lecture 5	6		
Credit points	6				
Course achievement	None				
Examination					
Examination duration and scale					
Assignment for the Following Curricula	Computer Science: Specialisation III. Mathematics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective				

Compulsory

Course L1247: Num	nerics of Partial Differential Equations
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	DE/EN
Cycle	WiSe
Content	<ul> <li>Elementary Theory and Numerics of PDEs</li> <li>types of PDEs</li> <li>well posed problems</li> <li>finite differences</li> <li>finite elements</li> <li>finite volumes</li> <li>applications</li> </ul>
Literature	Dietrich Braess: Finite Elemente: Theorie, schnelle Löser und Anwendungen in der Elastizitätstheorie, Berlin u.a., Springer 2007 Susanne Brenner, Ridgway Scott: The Mathematical Theory of Finite Element Methods, Springer, 2008 Peter Deuflhard, Martin Weiser: Numerische Mathematik 3

Course L1248: Numerics of Partial Differential Equations		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	NN	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses								
<b>Title</b> Matrix Algorithms (L09	84)				Typ Lecture	Castia	Hrs/wk	<b>CP</b> 3
Matrix Algorithms (L09	85)				Recitation (small)	Section	12	3
		ns-Peter Z	Zemke					
Admission Requirements	None							
Recommended Previous Knowledge	•		al Mathemat	ics 1/ Numeri he programm		s Matlab	and C	
Educational Objectives	After	taking paı	rt successful	ly, students h	ave reached	the follo	wing learn	ing results
Professional Competence								
Knowledge	<ol> <li>name, state and classify state-of-the-art Krylov subspace methods for the solution of the core problems of the engineering sciences, namely, eigenvalue problems, solution of linear systems, and model reduction;</li> <li>state approaches for the solution of matrix equations (Sylvester, Lyapunov, Riccati).</li> </ol>							
Skills	<ol> <li>implement and assess basic Krylov subspace methods for the solution of eigenvalue problems, linear systems, and model reduction;</li> <li>assess methods used in modern software with respect to computing time stability, and domain of applicability;</li> <li>adapt the approaches learned to new, unknown types of problem.</li> </ol>							
Personal Competence								
	Stude	nts can						
Social Competence	•	form gro applicab	ups to furtheility;	nt joint solution the develop the loop, build, and	e ideas and t	ransfer t		her areas o
Autonomy	<ul> <li>Students are able to</li> <li>correctly assess the time and effort of self-defined work;</li> <li>assess whether the supporting theoretical and practical excercises are better solved individually or in a team;</li> <li>define test problems for testing and expanding the methods;</li> <li>assess their individual progess and, if necessary, to ask questions and seek help.</li> </ul>							
Workload in Hours		endent St	udy Time 12	4, Study Time	e in Lecture 5	6		
Credit points Course								
achievement								

Examination duration and scale	
the Following	

Course L0984: Mat	rix Algorithms
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	<ul> <li>Part A: Krylov Subspace Methods:         <ul> <li>Basics (derivation, basis, Ritz, OR, MR)</li> <li>Arnoldi-based methods (Arnoldi, GMRes)</li> <li>Lanczos-based methods (Lanczos, CG, BiCG, QMR, SymmLQ, PvL)</li> <li>Sonneveld-based methods (IDR, BiCGStab, TFQMR, IDR(s))</li> </ul> </li> <li>Part B: Matrix Equations:         <ul> <li>Sylvester Equation</li> <li>Lyapunov Equation</li> <li>Algebraic Riccati Equation</li> </ul> </li> </ul>
Literature	Skript

Course L0985: Matrix Algorithms		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Jens-Peter Zemke	
Language	DE/EN	
Cycle	WiSe	
Content		
Literature	Siehe korrespondierende Vorlesung	

Courses				
Title		Тур	Hrs/wk	СР
Integrated Product Development II (L1254)		Lecture	3	3
Integrated Product De	velopment II (L1255)	Project-/problem- based Learning	2	3
Module Responsible	Prof. Dieter Krause			
Admission Requirements	LNODE			
Recommended Previous Knowledge	Basic knowledge of Integrated product development and applying CAE systems			
Educational Objectives	Tarrar raying harr circoccritily, crindnic have reached the following learning recilire			
Professional				
Competence	<u> </u>			
	After passing the module students	are able to:		
Knowledge	<ul> <li>explain technical terms of design methodology,</li> <li>describe essential elements of construction management,</li> <li>describe current problems and the current state of research of integrate product development.</li> </ul>			
	After passing the module students are able to:			
Skills	<ul> <li>select and apply proper construction methods for non-standardized solution of problems as well as adapt new boundary conditions,</li> <li>solve product development problems with the assistance of a worksho based approach,</li> <li>choose and execute appropriate moderation techniques.</li> </ul>			
Personal				
Competence				
	After passing the module students	are able to:		
Social Competence	<ul> <li>prepare and lead team meetings and moderation processes,</li> <li>work in teams on complex tasks,</li> <li>represent problems and solutions and advance ideas.</li> </ul>			
	After passing the module students	are able to:		
A			h a al c	
Autonomy	<ul> <li>give a structured feedback and accept a critical feedback,</li> <li>implement the accepted feedback autonomous.</li> </ul>			
Workload in Hours	Independent Study Time 110, Stud	y Time in Lecture 70		
Credit points				
Course achievement	None			
Examination				
Examination duration and scale	30 Minuten			
Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Comparing Aircraft Systems Engineering: Specialisation Air Transportation Systems Compulsory International Management and Engineering: Specialisation II. Product Defand Production: Elective Compulsory				ns: Electiv

### **Assignment for** the Following Curricula

Mechatronics: Specialisation System Design: Elective Compulsory

Materials and Product Development, Production: Specialisation **Product** 

**Development: Compulsory** 

Product Development, Materials and Production: Specialisation Production: Elective

Compulsory

Product Development, Materials and Production: Specialisation Materials: Elective

Compulsory

Theoretical Mechanical Engineering: Technical Complementary Course: Elective

Compulsory

Theoretical Mechanical Engineering: Specialisation Product Development and

**Production: Elective Compulsory** 

## Course L1254: Integrated Product Development II **Typ** Lecture

Hrs/wk 3

**CP** 3

Workload in Hours Independent Study Time 48, Study Time in Lecture 42

**Lecturer** Prof. Dieter Krause

Language DE

Cycle WiSe

### Lecture

The lecture extends and enhances the learned content of the module "Integrated Product Development and lightweight design" and is based on the knowledge and skills acquired there.

Topics of the course include in particular:

- Methods of product development,
- Presentation techniques,
- Industrial Design.
- Design for variety
- Modularization methods,
- Design catalogs,
- Adapted QFD matrix,
- Systematic material selection,
- · Assembly oriented design,

### Construction management

### Content

- CE mark, declaration of conformity including risk assessment,
- Patents, patent rights, patent monitoring
- Project management (cost, time, quality) and escalation principles,
- Development management for mechatronics,
- Technical Supply Chain Management.

### **Exercise (PBL)**

In the exercise the content presented in the lecture "Integrated Product Development II" and methods of product development and design management will be enhanced.

Students learn an independently moderated and workshop based approach through industry related practice examples to solve complex and currently existing issues in product development. They will learn the ability to apply important methods of product development and design management autonomous and acquire further expertise in the field of integrated product development. Besides personal skills, such as teamwork, guiding discussions and representing work results will be acquired through the workshop based structure of the event under its own planning and management.

Literature	<ul> <li>Andreasen, M.M., Design for Assembly, Berlin, Springer 1985.</li> <li>Ashby, M. F.: Materials Selection in Mechanical Design, München, Spektrum 2007.</li> <li>Beckmann, H.: Supply Chain Management, Berlin, Springer 2004.</li> <li>Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater und Trainer, Weinheim, Beltz 2007.</li> <li>Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006.</li> <li>Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000.</li> <li>Simpson, T.W., Siddique, Z., Jiao, R.J.: Product Platform and Product Family Design. Methods and Applications, New York, Springer 2013.</li> </ul>
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Course L1255: Integrated Product Development II		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Dieter Krause	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses				
Title		Tym	Hac hade	CD
The Digital Enterprise	(10932)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 2
Production Planning ar		Lecture	2	2
Production Planning ar	nd Control (L0930)	Recitation	Section 1	1
Exercise: The Digital E	nterprise (L0933)	(small) Recitation (small)	Section 1	1
Module	Prof. Hermann Lödding	(Siriall)		
Responsible Admission				
Requirements	None			
Recommended Previous Knowledge	Fundamentals of Production and Qu	ality Managemen	t	
Educational Objectives	After taking part successfully, stude	nts have reached	the following learn	ing results
Professional Competence				
Knowledge	Students can explain the contents of the module in detail and take a critical position to them.			
Skills	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
Social Competence	Students can develop joint solutions	in mixed teams a	and present them t	o others.
Autonomy	-			
Norkload in Hours	Independent Study Time 96, Study	Time in Lecture 84	1	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
Assignment for the Following Curricula				

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0932: The	Digital Enterprise
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	Due to the developments of Industry 4.0, digitalization and interconnectivity become a strategic advantage for companies in the international competition. This lecture focuses on the relevant modules and enables the participants to evaluate current developments in this context. In particular, knowledge management, simulation, process modelling and virtual technologies are covered.  Content:  Business Process Management and Data Modelling, Simulation Knowledge and Competence Management Process Management (PPC, Workflow Management) Computer Aided Planning (CAP) and NC-Programming Virtual Reality (VR) and Augmented Reality (AR) Computer Aided Quality Management (CAQ) Industry 4.0
Literature	Scheer, AW.: ARIS - vom Geschäftsprozeß zum Anwendungssystem. Springer-Verlag, Berlin 4. Aufl. 2002  Schuh, G. et. al.: Produktionsplanung und -steuerung, Springer-Verlag. Berlin 3. Auflage 2006  Becker, J.; Luczak, H.: Workflowmanagement in der Produktionsplanung und -steuerung. Springer-Verlag, Berlin 2004  Pfeifer, T; Schmitt, R.: Masing Handbuch Qualitätsmanagement. Hanser-Verlag, München 5. Aufl. 2007  Kühn, W.: Digitale Fabrik. Hanser-Verlag, München 2006

Course L0929: Production Planning and Control		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Hermann Lödding	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Models of Production and Inventory Management</li> <li>Production Programme Planning and Lot Sizing</li> <li>Order and Capacity Scheduling</li> <li>Selected Strategies of PPC</li> <li>Manufacturing Control</li> <li>Production Controlling</li> <li>Supply Chain Management</li> </ul>	
Literature	<ul> <li>Vorlesungsskript</li> <li>Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008</li> <li>Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002</li> </ul>	

Course L0930: Production Planning and Control		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Hermann Lödding	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0933: Exercise: The Digital Enterprise			
Тур	Typ Recitation Section (small)		
Hrs/wk	1		
СР	1		
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Dr. Axel Friedewald		
Language	DE		
Cycle			
Content	See interlocking course		
Literature	Siehe korrespondierende Vorlesung See interlocking course		

Module M081	5: Product Planning			
Courses				
Title		Тур	Hrs/wk	СР
Product Planning (L085	51)	Project-/problem- based Learning	3	3
Product Planning Semi	inar (L0853)	Project-/problem- based Learning	2	3
Module Responsible	TPINE COMPINE REISTAIL			
Admission Requirements				
Recommended Previous Knowledge	Good basic-knowledge of Business Adn	ninistration		
Educational Objectives	TAHER TAKING DARI SHICLESSIIIIV SHIGENIS	s have reached the foll	owing learn	ing results
Professional Competence				
Knowledge	Students will gain insights into:  • Product Planning  • Process  • Methods  • Design thinking  • Process  • Methods  • User integration			
Skills	Students will gain deep insights into:  • Product Planning  • Process-related aspects  • Organisational-related as  • Human-Ressource related  • Working-tools, methods a	d aspects		
Personal Competence				
Social Competence	<ul><li>Interact within a team</li><li>Raise awareness for globabl issu</li></ul>	ues		
Autonomy	<ul> <li>Gain access to knowledge sourc</li> <li>Interpret complex cases</li> <li>Develop presentation skills</li> </ul>	es		
<b>Workload in Hours</b>	Independent Study Time 110, Study Ti	me in Lecture 70		
Credit points				
Course achievement	Cubiact than	<b>Descrip</b> pretical and	tion	
Examination	Written exam			
Examination duration and scale	90 minutes			
	<u> </u> 			

	Global Innovation Management: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective
Assignment for the Following Curricula	Compulsory  Product Development Materials and Production: Specialisation Product
	Production: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0851: Prod	duct Planning			
Тур	Typ Project-/problem-based Learning			
Hrs/wk	3			
СР	3			
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42			
Lecturer	Prof. Cornelius Herstatt			
Language	EN			
Cycle	WiSe			
	Product Planning Process  This integrated lecture is designed to understand major issues, activities and tools in the context of systematic product planning, a key activity for managing the frontend of innovation, i.e.:  • Systematic scanning of markets for innovation opportunities  • Understanding strengths/weakness and specific core competences of a firm as platforms for innovation  • Exploring relevant sources for innovation (customers, suppliers, Lead Users, etc.)  • Developing ideas for radical innovation, relying on the creativeness of employees, using techniques to stimulate creativity and creating a stimulating environment  • Transferring ideas for innovation into feasible concepts which have a high market attractively			
Content	Voluntary presentations in the third hour (articles / case studies) - Guest lectures by researchers			
	- Lecture on Sustainability with frequent reference to current research			
	- Permanent reference to current research			
	Examination:			
	In addition to the written exam at the end of the module, students have to attend the PBL-exercises and prepare presentations in groups in order to pass the module. Additionally, students have the opportunity to present research papers on a voluntary base. With these presentations it is possible to gain a bonus of max. 20% for the exam. However, the bonus is only valid if the exam is passed without the bonus.			
Literature	Ulrich, K./Eppinger, S.: Product Design and Development, 2nd. Edition, McGraw-Hill 2010			

Course L0853: Product Planning Seminar		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Cornelius Herstatt	
Language	EN	
Cycle	WiSe	
Content	Seminar is integrative part of the Module Product Planning (for content see lecture) and can not be choosen independantly.	
Literature	See lecture information "Product Planning".	

Module M0739	9: Factory Planning & Pro	oduction Logi	stics		
Courses					
<b>Title</b> Factory Planning (L144 Production Logistics (L		<b>Typ</b> Lecture Lecture	<b>Hrs/wk</b> 3 2	<b>CP</b> 3 3	
Admission Requirements	None				
Recommended Previous Knowledge					
Educational Objectives	After taking part successfully, stude	nts have reached th	e following learn	ing results	
Professional Competence					
	The students will acquire the following knowledge:  1. The students know the latest trends and developments in the planning of factories.				
Knowledge	2. The students can explain basic deploy these procedures while consi			are able to	
	3. The students know different methods of factory planning and are able to deal critically with these methods.				
	The students will acquire the following skills:  1. The students are able to analyze factories and other material flow systems vegard to new development and the need for change of these logistical systems.				
Skills	2. The students are able to plan and systems.	d redesign factories	and other mate	rial handling	
	3. The students are able to develop procedures for the implementation of new and revised material flow systems.				
Personal Competence					
	The students will acquire the followi 1. The students are able to devimprovement of existing material flo	elop plans for the		of new and	
Social Competence	<ol><li>The developed planning proposal from the group work can be documented and presented together.</li></ol>				
	3. The students are able to derive suggestions for improvement from the feedback on the planning proposals and can even provide constructive criticism themselves.				
	The students will acquire the followi  1. The students can plan and re planning procedures.			ing existing	
Autonomy	2. The students can evaluate ind several techniques for factory planr context.				
3. The students are able to carry out autonomously new plans and transformation of material flow systems.				sformations	

<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Elective Compulsory

Course L1445: Fact	tory Planning	
Тур	Lecture	
Hrs/wk	3	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Prof. Jochen Kreutzfeldt	
Language	DE	
Cycle	WiSe	
	The lecture gives an introduction into the planning of factories and material flows. The students will learn process models and methods to plan new factories and improve existing material flow systems. The course includes three basic topics: (1) Analysis of factory and material flow systems	
	(2) Development and re-planning of factory and material flow systems	
Content	(3) Implementation and realization of factory planning	
Content	The students are introduced into several different methods and models per topic. Practical examples and planning exercises deepen the methods and explain the application of factory planning.	
	The special requirements of factory planning in an international context are discussed. Specific requirements of Current trends and issues in the factory planning round off the lecture.	
	Bracht, Uwe; Wenzel, Sigrid; Geckler, Dieter (2018): Digitale Fabrik: Methoden und Praxisbeispiele. 2. Aufl.: Springer, Berlin.	
	Helbing, Kurt W. (2010): Handbuch Fabrikprojektierung. Berlin, Heidelberg: Springer Berlin Heidelberg.	
	Lotter, Bruno; Wiendahl, Hans-Peter (2012): Montage in der industriellen Produktion: Optimierte Abläufe, rationelle Automatisierung. 2. Aufl.: Springer, Berlin.	
Literature	Müller, Egon; Engelmann, Jörg; Löffler, Thomas; Jörg, Strauch (2009): Energieeffiziente Fabriken planen und betreiben. Berlin, Heidelberg: Springer Berlin Heidelberg.	
Literature	Schenk, Michael; Müller, Egon; Wirth, Siegfried (2014): Fabrikplanung und Fabrikbetrieb. Methoden für die wandlungsfähige, vernetzte und ressourceneffiziente Fabrik. 2. Aufl. Berlin [u.a.]: Springer Vieweg.	
	Wiendahl, Hans-Peter; Reichardt, Jürgen; Nyhuis, Peter (2014): Handbuch Fabrikplanung: Konzept, Gestaltung und Umsetzung wandlungsfähiger Produktionsstätten. 2. Aufl. Carl Hanser Verlag.	

Course L1446: Prod	luction Logistics
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	DiplIng. Arnd Schirrmann
Language	DE
Cycle	WiSe
Content	<ul> <li>Introduction: situation, significance and main innovation focuses of logistics in a production company, aspects of procurement, production, distribution and disposal logistics, production and transport networks</li> <li>Logistics as a production strategy: logistics-oriented method of working in a factory, throughput time, corporate strategy, structured networking, reducing complexity, integrated organization, integrated product and production logistics (IPPL)</li> <li>Logistics-compatible production and process structuring; logistics-compatible product, material flow, information and organizational structures</li> <li>Logistics-oriented production control: situation and development tendencies, logistics and cybernetics, market-oriented production planning, control, monitoring, PPS systems and production control, cybernetic production organization and control, production logistics control systems.</li> <li>Production logistics planning: key performance indicators, developing a production logistics planning: key performance indicators, developing a production logistics concept, computerized aids to planning production logistics, IPPL functions, economic efficiency of logistics projects</li> <li>Production logistics controlling: production logistics and controlling, material flow-oriented cost transparency, cost controlling (process cost accounting, costs model in IPPL), process controlling (integrated production system, methods and tools, MEPOT.net method portal)</li> </ul>
Literature	Pawellek, G.: Produktionslogistik: Planung - Steuerung - Controlling. Carl Hanser Verlag 2007

	3: Laser systems and	methods of man	nufacturing	g design
and analysis				
Courses				
Title		Тур	Hrs/wk	СР
<u>-</u>	cess Technologies (L1612)	Lecture	2	3
Methods for Analysing	Production Processes (L0876)	Lecture	2	3
Module Responsible	Prof. Wolfgang Hintze			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, st	udents have reached the	following learn	ning results
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
<b>Workload in Hours</b>	Independent Study Time 124, St	udy Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Product Development, Mate Development: Elective Compulsor Product Development, Materials Compulsory Product Development, Materials Compulsory Theoretical Mechanical Engine Production: Elective Compulsory Theoretical Mechanical Engine Compulsory	ory lals and Production: s and Production: Special eering: Specialisation P	Specialisation alisation Materi Product Develo	Production als: Elective

Course L1612: Lase	Course L1612: Laser Systems and Process Technologies		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Claus Emmelmann		
Language	EN		
Cycle	WiSe		
Content	<ul> <li>Fundamentals of laser technology</li> <li>Laser beam sources: CO2-, Nd:YAG-, Fiber- and Diodelasers</li> <li>Laser system technology: beam forming, beam guidance systems, beam motion and beam control</li> <li>Laser-based manufacturing technologies: generation, marking, cutting, joining, surface treatment</li> <li>Quality assurance and economical aspects of laser material processing</li> <li>Markets and Applications of laser technology</li> <li>Student group exercises</li> </ul>		
Literature	<ul> <li>Hügel, H., T. Graf: Laser in der Fertigung: Strahlquellen, Systeme, Fertigungsverfahren, 3. Aufl., Vieweg + Teubner Wiesbaden 2014.</li> <li>Eichler, J., Eichler. H. J.: Laser: Bauformen, Strahlführung, Anwendungen, 7. Aufl., Springer-Verlag Berlin Heidelberg 2010.</li> <li>Steen W. M.; Mazumder J.: Laser material processing, 4th Edition, Springer-Verlag London 2010.</li> <li>J.C. Ion: Laser processing of engineering materials: principles, procedure and industrial applications, Elsevier Butterworth-Heinemann 2005.</li> <li>Gebhardt, A.: Understanding additive manufacturing, München [u.a.] Hanser 2011</li> </ul>		

Course L0876: Met	hods for Analysing Production Processes
	Lecture
Hrs/wk	
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Wolfgang Hintze
Language	DE
Cycle	WiSe
Content	<ul> <li>Modelling and simulation of maching and forming processes</li> <li>Numerical simulation of forces, temperatures, deformation in machining</li> <li>Analysis of vibration problems in maching (chatter, modal analysis,)</li> <li>Knowledge based process planning</li> <li>Design of experiments</li> <li>Machinability of nonmetallic materials</li> <li>Analysis of interaction between maching process and machine tool systems with regard to process stability and quality</li> <li>Simulation of maching processes by virtual reality methods</li> </ul>
Literature	Tönshoff, H.K.; Denkena, B.; Spanen Grundlagen, Springer (2004)  Klocke, F.; König, W.; Fertigungsverfahren Umformen, Springer (2006)  Weck, M.; Werkzeugmaschinen Fertigungssysteme 3, Springer (2001)  Weck, M.; Werkzeugmaschinen Fertigungssysteme 5, Springer (2001)

Courses					
<b>Title</b> Fluidics (L1256)			<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Fluidics (L1371)			Project-/problem- based Learning	1	2
Fluidics (L1257)			Recitation Section (large)	<sup>511</sup> 1	1
itesponsible					
Admission Requirements	None				
	Good knowledge o kinematics and kinetion				nydrostatic
Educational Objectives	After taking part succ	essfully, students h	ave reached the foll	owing learn	ing results
Professional Competence		dule students are al	ole to		
Knowledge	hydrodynamic explain the inte explain open a describe functi	components, eraction of hydraulion nd closed loop cont ioning and applica	nalities of hydrosic c components in hydrolof hydraulic syste tions of hydrodyna centrifugal pumps a	Iraulic systeems, mic torque	ems, convertei
Skills	<ul> <li>design and dim</li> <li>perform nume problem definit</li> <li>select and adap</li> </ul>	sess hydraulic and nension hydraulic sy rical simulations cions, pt pump characteris	pheumatic componerstems for mechanic of hydraulic syster stic curves for hydra converters and b	al applications based ulic system	ons, on abstra s
Personal Competence	After passing the mod	dule students are al	ole to		
Social Competence		esent functional cor work autonomously			
Autonomy	After passing the mod  obtain necessa	dule students are ak ry knowledge for th			
	Independent Study Ti	me 124, Study Tim	e in Lecture 56		
Credit points	1.0				

Course achievement		None	Attestation	Simulation Systeme	hydrostatischer
Examination	Written exa	m			
Examination duration and scale	90				
Assignment for the Following Curricula	Compulsory International and Product Development Product Development Product Development D	al Managemicion: Elective pevelopment, velopment, velopment, Mechanical	Materials and Production: Sp Materials and Production: S Engineering: Technical Co I Engineering: Specialisati	alisation II. Production: Special pecialisation Prospecialisation Macomplementary	uct Development isation Product oduction: Elective laterials: Elective Course: Elective

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Course L1256: Flui	dics
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	WiSe
	Lecture
	Hydrostatics
	<ul> <li>physical fundamentals</li> <li>hydraulic fluids</li> <li>hydrostatic machines</li> <li>valves</li> <li>components</li> <li>hydrostatic transmissions</li> <li>examples from industry</li> </ul> Pneumatics <ul> <li>generation of compressed air</li> <li>pneumatic motors</li> <li>Examples of use</li> </ul> Hydrodynamics <ul> <li>physical fundamentals</li> <li>hydraulic continous-flow machines</li> <li>hydrodynamic transmissions</li> </ul>
	interoperation of motor and transmission
	Exercise
Content	<ul> <li>Hydrostatics</li> <li>reading and design of hydraulic diagrams</li> <li>dimensioning of hydrostatic traction and working drives</li> <li>performance calculation</li> </ul>

### Hydrodynamics

- calculation / dimensioning of hydrodynamic torque converters
- calculation / dimensioning of centrifugal pumps
- creating and reading of characteristic curves of pumps and systems

### Field trip

• field trip to a regional company from the hydraulic industry.

### **Exercise**

Numerical simulation of hydrostatic systems

- getting to know a numerical simulation environment for hydraulic systems
- transformation of a task into a simulation model
- simulation of common components
- variation of simulation parameters
- using simulations for system dimensioning and optimisation
- (partly) self-organised teamwork

### Bücher

# Literature

- Murrenhoff, H.: Grundlagen der Fluidtechnik Teil 1: Hydraulik, Shaker Verlag, Aachen, 2011
- Murrenhoff, H.: Grundlagen der Fluidtechnik Teil 2: Pneumatik, Shaker Verlag, Aachen, 2006
- Matthies, H.J. Renius, K.Th.: Einführung in die Ölhydraulik, Teubner Verlag, 2006
- Beitz, W., Grote, K.-H.: Dubbel Taschenbuch für den Maschinenbau, Springer-Verlag, Berlin, aktuelle Auflage

Skript zur Vorlesung

# Course L1371: Fluidics Typ Project-/problem-based Learning Hrs/wk 1 CP 2 Workload in Hours Independent Study Time 46, Study Time in Lecture 14 Lecturer Prof. Dieter Krause Language DE Cycle WiSe Content See interlocking course Literature See interlocking course

Course L1257: Fluidics		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Dieter Krause	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0563	3: Robotics				
Courses					
<b>Title</b> Robotics: Modelling an Robotics: Modelling an		Typ Lecture Recitation (small)	Section	<b>Hrs/wk</b> 3	<b>CP</b> 3
Module Responsible	Prof. Uwe Weltin				
Admission Requirements	None				
	Fundamentals of electrical engineering				
Recommended	Broad knowledge of mechanics				
Knowledge	Fundamentals of control theory				
Educational Objectives	After taking part successfully, students h	ave reached t	the follow	wing learn	ing results
Professional					
<b>Competence</b> <i>Knowledge</i>	Students are able to describe fundar		rties of	robots a	nd solution
	Students are able to derive and solve eq	uations of mot			anipulators.
Skills	Students can generate trajectories in var	ious coordina	te syste	ms.	
	Students can design linear and pamanipulators.	rtially nonlin	near co	ntrollers	for robotic
Personal Competence					
Social Competence	Students are able to work goal-oriented i		•		
	Students are able to recognize and impro	ove knowledge	e deficits	s independ	dently.
Autonomy	With instructor assistance, students are and define a further course of study.	able to evalua	ate their	own knov	wledge level
<b>Workload in Hours</b>	Independent Study Time 110, Study Time	e in Lecture 7	0		
Credit points					
Course achievement					
-	Written exam				
Examination duration and scale					
the Following	Aircraft Systems Engineering: Specialisal International Management and Engineer Compulsory International Management and Engineer and Production: Elective Compulsory Mechanical Engineering and Management Mechatronics: Core qualification: Compul Product Development, Materials a Development: Elective Compulsory Product Development, Materials and Procompulsory Product Development, Materials and Procompulsory	ing: Specialisating: Specialisating: Specialisating: Core qualificing production of the control	ation II. I ation II. cation: ( on: Sp ialisatio	Mechatron Product D Compulsor pecialisation n Producti	evelopment  y  n Product  ion: Elective
· ·					

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0168: Rob	Course L0168: Robotics: Modelling and Control		
Тур	Lecture		
Hrs/wk	3		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42		
Lecturer	Prof. Uwe Weltin		
Language	EN		
Cycle	WiSe		
Content	Fundamental kinematics of rigid body systems  Newton-Euler equations for manipulators  Trajectory generation  Linear and nonlinear control of robots		
Literature	Craig, John J.: Introduction to Robotics Mechanics and Control, Third Edition, Prentice Hall. ISBN 0201-54361-3  Spong, Mark W.; Hutchinson, Seth; Vidyasagar, M.: Robot Modeling and Control. WILEY. ISBN 0-471-64990-2		

Course L1305: Robotics: Modelling and Control		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Uwe Weltin	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0800 Methods)	6: Technical Acoustics II (Ro	oom Acous	stics, Compu	itational
Courses				
		Тур	Hrs/wk	СР
	(Room Acoustics, Computational Methods)	Lecture	2	3
Technical Acoustics II (L0521)	(Room Acoustics, Computational Methods)	Recitation (large)	Section 2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
·	Technical Acoustics I (Acoustic Waves, I	Noise Protection	on, Psycho Acoustic	cs)
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Kinematics, Dynamics)	Materials) and	d Mechanics II (F	Hydrostatics,
Knowieuge	Mathematics I, II, III (in particular differe	ential equation	s)	
Educational Objectives	After taking part successfully, students	have reached	the following learr	ning results
Professional				
Competence				
Knowledge	The students possess an in-depth know and computational methods and are al theoretical and methodical basis.			
Skills	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding computational methods and procedures treated within the module.			
Personal				
Competence				
Social Competence	Students can work in small groups on s	pecific problen	ns to arrive at joint	solutions.
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible conflicting issues and limitations can be identified and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Tir	ne in Lecture 5	56	
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	20-30 Minuten			
Assignment for the Following Curricula		sign: Elective d Production: Technical Com	Compulsory Core qualification	on: Elective

Course L0519: Tec	hnical Acoustics II (Room Acoustics, Computational Methods)		
Тур	Lecture		
Hrs/wk			
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Otto von Estorff		
Language	EN		
Cycle	WiSe		
Content	<ul> <li>Room acoustics</li> <li>Sound absorber</li> <li>Standard computations</li> <li>Statistical Energy Approaches</li> <li>Finite Element Methods</li> <li>Boundary Element Methods</li> <li>Geometrical acoustics</li> <li>Special formulations</li> <li>Practical applications</li> <li>Hands-on Sessions: Programming of elements (Matlab)</li> </ul>		
Literature	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin		

Course L0521: Technical Acoustics II (Room Acoustics, Computational Methods)		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Otto von Estorff	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1150	D: Continuum Mechanics			
Courses				
<b>Title</b> Continuum Mechanics Continuum Mechanics		Typ Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	(forces and moments, stress, linear	Basics of linear continuum mechanics as taught, e.g., in the module Mechanics II (forces and moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy).		
Educational Objectives	LATTAL TAKING NATT CHECACCTHIN CTHOANTC N	ave reached	the following learr	ning results
Professional Competence				
Knowledge	The students can explain the fundame behavior of materials.	The students can explain the fundamental concepts to calculate the mechanical behavior of materials.		
Skills	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.			
Personal Competence Social Competence	The students are able to develop solutions, to present them to specialists in written form and to develop ideas further.			
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of continuum mechanics and acquire the knowledge required to this end.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	INONE			
Examination	Written exam			
Examination duration and scale				
	Materials Science: Specialisation Modelin Mechanical Engineering and Manage Compulsory Mechatronics: Technical Complementary Biomedical Engineering: Specialisation A Elective Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Elective Compulsory	ement: Speci Course: Elect rtificial Orgar Implants a	alisation Materia tive Compulsory ns and Regeneration	ve Medicine: es: Elective
	Biomedical Engineering: Specialisation	Management	and Business Ad	ministration:

Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective
Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L1533: Con	tinuum Mechanics
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul> <li>kinematics of undeformed and deformed bodies</li> <li>balance equations (balance of mass, balance of energy,)</li> <li>stress states</li> <li>material modelling</li> </ul>
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer

Course L1534: Continuum Mechanics Exercise		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>kinematics of undeformed and deformed bodies</li> <li>balance equations (balance of mass, balance of energy,)</li> <li>stress states</li> <li>material modelling</li> </ul>	
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer	

Module M075	L: Vibration Theory
Courses	
<b>Title</b> Vibration Theory (L070)	Typ Hrs/wk CP Integrated Lecture 4 6
Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to denote terms and concepts of Vibration Theory and develop them further.
	Students are able to denote methods of Vibration Theory and develop them further.
Personal Competence	
· ·	Students can reach working results also in groups.
-	Students are able to approach individually research tasks in Vibration Theory.
-	Independent Study Time 124, Study Time in Lecture 56
Credit points Course	
achievement	None
Examination	Written exam
Examination duration and scale	
the Following	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L0701: Vibration Theory		
Тур	Integrated Lecture	
Hrs/wk	4	
СР	6	
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Norbert Hoffmann	
Language	DE/EN	
Cycle	WiSe	
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Oscillations and Waves.	
Literature	K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. Springer Verlag, 2013.	

Module M0832	2: Advanced Topics in Co	ontrol		
Courses				
<b>Title</b> Advanced Topics in Co Advanced Topics in Co		<b>Typ</b> Lecture Recitation (small)	Hrs/wk 2 Section 2	<b>CP</b> 3
Module Responsible	Prof. Herbert Werner	(Smail)		
Admission Requirements				
Recommended Previous Knowledge	H-infinity optimal control, mixed-se	nsitivity design, line	ear matrix inequa	lities
Educational Objectives	After taking part successfully, stude	ents have reached	the following lear	ning results
Professional Competence				
Knowledge	communication topology of r  They can explain the comprotocols  They can explain analysis an involving either LTI or LPV ag  Students can explain the s distributed systems that are  They can explain (in outline)	entation of nonlinear lity and performance and techniques can by stems applied and LFT representation of the concept of the co	er systems in the face conditions for be used to solve sentations of LPV ated with each of estate are used to response for formation of spatiang to an actuator of the bounded respectation of spatiang to an actuator of the bounded respectation of spatiang to an actuator of the bounded respectation of spatiang to an actuator of the bounded respectation of spatiang to an actuator of the spatial spa	form of quasi LPV systems analysis and systems and these mode epresent the r consensus control loops ally invariant /sensor array al lemma to
Skills	<ul> <li>such distributed systems distributed controllers</li> <li>Students are capable of cocarry out a mixed-sensitivity do this using polytopic, LFT of they are able to use standar for these tasks</li> <li>Students are able to design agents with either LTI or LPV</li> </ul>	onstructing LPV mo y design of gain-so or general LPV mod rd software tools (I	odels of nonlinea heduled controlle els Matlab robust cor tion controllers f	r plants and ers; they can atrol toolbox or groups o
	[530]			

	<ul> <li>Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox</li> </ul>				
Personal Competence					
Social Competence	Students can work in small groups and arrive at joint results.				
	Students are able to find required information in sources provided (lecture notes,				
	iterature, software documentation) and use it to solve given problems.				
Autonomy					
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and scale					
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory				

_	anced Topics in Control
	Lecture
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Herbert Werner
Language	
Cycle	wise
Content	<ul> <li>Linear Parameter-Varying (LPV) Gain Scheduling</li> <li>Linearizing gain scheduling, hidden coupling</li> <li>Jacobian linearization vs. quasi-LPV models</li> <li>Stability and induced L2 norm of LPV systems</li> <li>Synthesis of LPV controllers based on the two-sided projection lemma</li> <li>Simplifications: controller synthesis for polytopic and LFT models</li> <li>Experimental identification of LPV models</li> <li>Controller synthesis based on input/output models</li> <li>Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator</li> <li>Control of Multi-Agent Systems</li> <li>Communication graphs</li> <li>Spectral properties of the graph Laplacian</li> <li>First and second order consensus protocols</li> <li>Formation control, stability and performance</li> <li>LPV models for agents subject to nonholonomic constraints</li> <li>Application: formation control for a team of quadrotor helicopters</li> <li>Control of Spatially Interconnected Systems</li> <li>Multidimensional signals, I2 and L2 signal norm</li> <li>Multidimensional systems in Roesser state space form</li> <li>Extension of real-bounded lemma to spatially interconnected systems</li> <li>LMI-based synthesis of distributed controllers</li> <li>Spatial LPV control of spatially varying systems</li> <li>Applications: control of temperature profiles, vibration damping for ar actuated beam</li> </ul>
Literature	<ul> <li>Werner, H., Lecture Notes "Advanced Topics in Control"</li> <li>Selection of relevant research papers made available as pdf documents vi StudIP</li> </ul>

Course L0662: Advanced Topics in Control		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0603	3: Nonlinear Structural A	nalysis		
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Structural A	nalysis (L0277)	Lecture	3	4
Nonlinear Structural A	nalysis (L0279)	Recitation (small)	Section 1	2
Module Responsible	Prof. Alexander Düster			
Admission Requirements	None			
Recommended Previous Knowledge	Knowledge of partial differential equ	ations is recomme	nded.	
Educational Objectives	After taking part successfully, stude	nts have reached t	he following learn	ing results
Professional				
Competence				
Knowledge	Students are able to + give an overview of the different nonlinear phenomena in structural mechanics. + explain the mechanical background of nonlinear phenomena in structural mechanics. + to specify problems of nonlinear structural analysis, to identify them in a given situation and to explain their mathematical and mechanical background.			
Skills	Students are able to + model nonlinear structural problems. + select for a given nonlinear structural problem a suitable computational procedure. + apply finite element procedures for nonlinear structural analysis. + critically verify and judge results of nonlinear finite elements. + to transfer their knowledge of nonlinear solution procedures to new problems.			
Personal Competence				
Social Competence	Students are able to + solve problems in heterogeneouresults. + share new knowledge with group		document the co	orresponding
Autonomy	Students are able to + acquire independently knowledge	to solve complex p	oroblems.	
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 56	5	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
	Civil Engineering: Specialisation Stru International Management and En Elective Compulsory Materials Science: Specialisation Mo Mechatronics: Specialisation System	gineering: Special deling: Elective Co	isation II. Civil I	

Assignment for	Product	Development,	Materials	and	Production:	Core	qualification:	Elective
the Following	Compuls	ory						_
Curricula	Naval Ar	chitecture and ( Offshore Techr	Ocean Engii	neerir	g: Core quali	fication	n: Elective Com	pulsory
	Theoretic	cal Mechanical	Engineerir	ıg: Te	chnical Com	pleme	ntary Course:	Elective
	Compuls	ory						
	Theoretic	cal Mechanical I	Engineering	: Core	qualification	: Electi	ive Compulsory	′
	Theoretic	cal Mechanical	Engineering	g: Spe	cialisation Si	mulatio	on Technology:	Elective
	Compuls	ory						

Course L0277: Nonlinear Structural Analysis			
Тур	Lecture		
Hrs/wk	3		
СР	4		
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	Prof. Alexander Düster		
Language	DE/EN		
Cycle	WiSe		
Content	<ol> <li>Introduction</li> <li>Nonlinear phenomena</li> <li>Mathematical preliminaries</li> <li>Basic equations of continuum mechanics</li> <li>Spatial discretization with finite elements</li> <li>Solution of nonlinear systems of equations</li> <li>Solution of elastoplastic problems</li> <li>Stability problems</li> <li>Contact problems</li> </ol>		
Literature	<ul> <li>[1] Alexander Düster, Nonlinear Structrual Analysis, Lecture Notes, Technische Universität Hamburg-Harburg, 2014.</li> <li>[2] Peter Wriggers, Nonlinear Finite Element Methods, Springer 2008.</li> <li>[3] Peter Wriggers, Nichtlineare Finite-Elemente-Methoden, Springer 2001.</li> <li>[4] Javier Bonet and Richard D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press, 2008.</li> </ul>		

Course L0279: Nonlinear Structural Analysis		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Alexander Düster	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0939	: Control La	ab A				
Courses						
Title				Тур	Hrs/wk	СР
Control Lab I (L1093)				Practical Course	1	1
Control Lab II (L1291)				Practical Course	1	1
Control Lab III (L1665)				Practical Course	1	1
Control Lab IV (L1666)				Practical Course	1	1
Module Responsible	Prof. Herbert We	rner				
Admission Requirements	None					
Recommended Previous Knowledge		ol infinity optima plant models a		control		
Educational Objectives	After taking part	successfully, s	students h	ave reached the fo	ollowing learn	ing results
Professional Competence						
Knowledge		can explain th and experime		nce between valid ation	ation of a co	ontrol lop in
Skills	System Id for contro They are for the de They are Toolbox) for optimal co They are implemen They are	entification Tooler synthesis capable of using and imple capable of usor the mixed-solution a robust capable of repairs of the design of the design.	ng standa mentation ing standa ensitivity of presenting ontroller ing standa	basic system ide dentify a dynamic rd software tools of LQG controllers ard software tools design and the imp model uncertains ard software tools implementation	model that of (Matlab Contests (Matlab Role) blementation by and of detailed Role (Matlab Role)	can be used rol Toolbox)  oust Control of H-infinity esigning and oust Control
Personal Competence						
Social Competence	<ul><li>Students results</li></ul>	can work in	teams to	conduct experim	ents and do	cument the
Autonomy		can independ ontrol loops	lently carı	ry out simulation	studies to	design and
Workload in Hours	Independent Stu	dy Time 64, St	udy Time	in Lecture 56		
Credit points	•	-	<del></del>			
Course achievement	None					
Examination	Written elaborat	on				
Examination						

duration and scale	
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L1093: Control Lab I		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Herbert Werner, Patrick Göttsch, Adwait Datar	
Language	EN	
Cycle	WiSe/SoSe	
Content	One of the offered experiments in control theory.	
	Experiment Guides	
Literature		

Course L1291: Con	Course L1291: Control Lab II		
Тур	Practical Course		
Hrs/wk	1		
СР	1		
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	rof. Herbert Werner, Patrick Göttsch, Adwait Datar		
Language	EN		
Cycle	WiSe/SoSe		
	One of the offered experiments in control theory.		
Literature	Experiment Guides		

Course L1665: Control Lab III		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	rof. Herbert Werner, Patrick Göttsch, Adwait Datar	
Language	EN	
Cycle	WiSe/SoSe	
	One of the offered experiments in control theory.	
Literature	Experiment Guides	

Course L1666: Control Lab IV		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Herbert Werner, Patrick Göttsch, Adwait Datar	
Language	EN	
Cycle	WiSe/SoSe	
	One of the offered experiments in control theory.	
Literature	Experiment Guides	

# Module M1043: Aircraft Systems Engineering

Courses					
Title		Тур		Hrs/wk	СР
Fatigue & Damage Tol	erance (L0310)	Lecture		2	3
Lightweight Design Practical Course (L1258)		Project-/probl based Learnir		3	3
Aviation Security (L1549)		Lecture	_	2	2
Aviation Security (L1550)		Recitation (small)	Section	1	1
Mechanisms, Systems and Processes of Materials Testing (L0950)		Lecture		2	2
Turbo Jet Engines (L0908)		Lecture		2	3
Structural Mechanics of Fibre Reinforced Composites (L1514)		Lecture		2	3
System Simulation (L1820)		Lecture	6 11	2	2
System Simulation (L1821)		Recitation (large)	Section	1	2
Materials Testing (L09		Lecture		2	2
Reliability in Engineering Dynamics (L0176)		Lecture		2	2
Reliability in Engineeri	ng Dynamics (L1303)	Recitation (small)	Section	1	2
Reliability of avionics a	assemblies (L1554)	Lecture		2	2
Reliability of avionics a		Recitation (small)	Section	1	1
Reliability of Aircraft S	ystems (L0749)	Lecture		2	3
Module Responsible	Prof. Frank Thielecke				
Admission	None				
Requirements	Basic knowledge in:				
Recommended Previous Knowledge	<ul> <li>Thermodynamics</li> </ul>				
Educational Objectives	After taking part successfully, students l	have reached	the follow	ving learr	ning results
Professional					
Competence					
Knowledge	<ul> <li>Students are able to find their way through selected special areas within systems engineering, air transportation system and material science</li> <li>Students are able to explain basic models and procedures in selected special areas.</li> <li>Students are able to interrelate scientific and technical knowledge.</li> </ul>				
Skills	I Students are able to apply basic method	ds in selected a	areas of e	engineeri	ng.
Personal					
Competence	i				
	Ti				
Social Competence	Students can chose independently, ir		they w	ant to c	leepen thei
Autonomy	Students can chose independently, ir knowledge and skills through the election		they w	ant to c	leepen thei
Autonomy	Students can chose independently, ir		they w	ant to c	leepen thei
Autonomy	Students can chose independently, in knowledge and skills through the election Depends on choice of courses		they w	ant to c	leepen thei

	Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory	
Assignment for	Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory	
the Following	International Management and Engineering: Specialisation II. Aviation Systems:	
	Elective Compulsory	
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective	
	Compulsory	
	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering:	
	Elective Compulsory	

Course L0310: Fatigue & Damage Tolerance		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
<b>Examination Form</b>	Mündliche Prüfung	
Examination duration and scale	45 min	
Lecturer	Dr. Martin Flamm	
Language	EN	
Cycle	WiSe	
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences	
Literature	Jaap Schijve, Fatigue of Structures and Materials. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989	

Course L1258: Lightweight Design Practical Course				
Тур	Project-/problem-based Learning			
Hrs/wk	3			
СР	3			
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42			
<b>Examination Form</b>	Mündliche Prüfung			
Examination duration and scale	30 min			
-	Prof. Dieter Krause			
Language				
Cycle				
Content	<ul> <li>Development of a sandwich structure made of fibre reinforced plastics</li> <li>getting familiar with fibre reinforced plastics as well as lightweight design</li> <li>Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA)</li> <li>Determination of material properties based on sample tests</li> <li>manufacturing of the structure in the composite lab</li> <li>Testing of the developed structure</li> <li>Concept presentation</li> <li>Self-organised teamwork</li> </ul>			
Literature	<ul> <li>Schürmann, H., "Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, 2005.</li> <li>Puck, A., "Festigkeitsanalsyse von Faser-Matrix-Laminaten", Hanser, München, Wien, 1996.</li> <li>R&amp;G, "Handbuch Faserverbundwerkstoffe", Waldenbuch, 2009.</li> <li>VDI 2014 "Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund"</li> <li>Ehrenstein, G. W., "Faserverbundkunststoffe", Hanser, München, 2006.</li> <li>Klein, B., "Leichtbau-Konstruktion", Vieweg &amp; Sohn, Braunschweig, 1989.</li> <li>Wiedemann, J., "Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, 1986.</li> <li>Wiedemann, J., "Leichtbau Band 2: Konstruktion", Springer, Berlin, Heidelberg, 1986.</li> <li>Backmann, B.F., "Composite Structures, Design, Safety and Innovation", Oxford (UK), Elsevier, 2005.</li> <li>Krause, D., "Leichtbau", In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012.</li> <li>Schulte, K., Fiedler, B., "Structure and Properties of Composite Materials", Hamburg, TUHH - TuTech Innovation GmbH, 2005.</li> </ul>			

Course L1549: Aviation Security	
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
Examination duration and scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization.  The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization:  • Historical development  • The special role of air transport  • Motive and attack vectors  • The human factor  • Threats and risk  • Regulations and law  • Organization and implementation of aviation security tasks  • Passenger and baggage checks  • Cargo screening and secure supply chain  • Safety technologies
Literature	<ul> <li>Skript zur Vorlesung</li> <li>Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011</li> <li>Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008</li> </ul>

Course L1550: Aviation Security	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
Examination duration and scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization.  The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization:  • Historical development  • The special role of air transport  • Motive and attack vectors  • The human factor  • Threats and risk  • Regulations and law  • Organization and implementation of aviation security tasks  • Passenger and baggage checks  • Cargo screening and secure supply chain  • Safety technologies
Literature	<ul> <li>Skript zur Vorlesung</li> <li>Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011</li> <li>Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008</li> </ul>

Course L0950: Mechanisms, Systems and Processes of Materials Testing	
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
Examination duration and scale	
Lecturer	Dr. Jan Oke Peters
Language	DE
Cycle	SoSe
Content	Application, analysis and discussion of basic and advanced testing methods to ensure correct selection of applicable testing procedure for investigation of part/materials deficiencies  Stress-strain relationships Strain gauge application Visko elastic behavior Tensile test (strain hardening, necking, strain rate) Compression test, bending test, torsion test Crack growth upon static loading (J-Integral) Crack growth upon cyclic loading (micro- und macro cracks) Effect of notches Creep testing (physical creep test, influence of stress and temperature, Larson Miller parameter) Wear testing Non destructive testing application for overhaul of jet engines
Literature	<ul> <li>E. Macherauch: Praktikum in Werkstoffkunde, Vieweg</li> <li>G. E. Dieter: Mechanical Metallurgy, McGraw-Hill</li> <li>R. Bürgel: Lehr- und Übungsbuch Festigkeitslehre, Vieweg</li> <li>R. Bürgel: Werkstoffe sícher beurteilen und richtig einsetzen, Vieweg</li> </ul>

Course L0908: Turbo Jet Engines	
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	
Lecturer	Dr. Burkhard Andrich
Language	DE
Cycle	WiSe
Content	<ul> <li>Cycle of the gas turbine</li> <li>Thermodynamics of gas turbine components</li> <li>Wing-, grid- and stage-sizing</li> <li>Operating characteristics of gas turbine components</li> <li>Sizing criteria's for jet engines</li> <li>Development trends of gas turbines and jet engines</li> <li>Maintenance of jet engines</li> </ul>
Literature	<ul> <li>Bräunling: Flugzeugtriebwerke</li> <li>Engmann: Technologie des Fliegens</li> <li>Kerrebrock: Aircraft Engines and Gas Turbines</li> </ul>

Course L1514: Stru	ctural Mechanics of Fibre Reinforced Composites
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	
	Classical laminate theory
	Rules of mixture
	Failure mechanisms and criteria of composites
	Boundary value problems of isotropic and anisotropic shells
Content	Stability of composite structures
	Optimization of laminated composites
	Modelling composites in FEM
	Numerical multiscale analysis of textile composites
	Progressive failure analysis
Literature	<ul> <li>Schürmann, H., "Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage.</li> <li>Wiedemann, J., "Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, aktuelle Auflage.</li> <li>Reddy, J.N., "Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition.</li> <li>Jones, R.M., "Mechanics of Composite Materials", Scripta Book Co., Washington, current edition.</li> <li>Timoshenko, S.P., Gere, J.M., "Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition.</li> <li>Turvey, G.J., Marshall, I.H., "Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition.</li> <li>Herakovich, C.T., "Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition.</li> <li>Mittelstedt, C., Becker, W., "Strukturmechanik ebener Laminate", aktuelle Auflage.</li> </ul>

Course L1820: System Simulation	
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.  • Instruction and modelling of physical processes • Modelling and limits of model • Time constant, stiffness, stability, step size • Terms of object orientated programming • Differential equations of simple systems • Introduction into Modelica • Introduction into simulation tool • Example: Hydraulic systems and heat transfer • Example: System with different subsystems
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</li> <li>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</li> <li>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</li> </ul>

Course L1821: System Simulation	
Тур	Recitation Section (large)
Hrs/wk	1
СР	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0949	: Materials Testing
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	IKIAUSUr
Examination duration and scale	90 Minuten
Lecturer	Dr. Jan Oke Peters
Language	DE
Cycle	WiSe
Content	Application and analysis of basic mechanical as well as non-destructive testing of materials  • Determination elastic constants • Tensile test • Fatigue test (testing with constant stress, strain, or plastiv strain amplitude, low and high cycle fatigue, mean stress effect) • Crack growth upon static loading (stress intensity factor, fracture toughness) • Creep test • Hardness test • Charpy impact test • Non destructive testing
Literature	E. Macherauch: Praktikum in Werkstoffkunde, Vieweg G. E. Dieter: Mechanical Metallurgy, McGraw-Hill

Course L0176: Reliability in Engineering Dynamics	
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
Examination duration and scale	
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	<ul> <li>Method for calculation and testing of reliability of dynamic machine systems</li> <li>Modeling</li> <li>System identification</li> <li>Simulation</li> <li>Processing of measurement data</li> <li>Damage accumulation</li> <li>Test planning and execution</li> </ul>
Literature	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4  Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737  Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936.  VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412

Course L1303: Reliability in Engineering Dynamics	
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1554: Reliability of avionics assemblies	
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Examination Form</b>	Klausur
Examination duration and scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:  • Survey of the role of electronics in aviation  • System levels: From silicon to mechatronic systems  • Semiconductor components, assemblies, systems  • Challenges of electronic packaging technology (AVT)  • System integration in electronics: Requirements for AVT  • Methods and techniques of AVT  • Error patterns for assemblies and avoidance of errors  • Reliability analysis for printed circuit boards (PCBs)  • Reliability of Avionics  • COTS, ROTS, MOTS and the F <sup>3</sup> I concept  • Future challenges for electronics
Literature	- Skript zur Vorlesung  Hanke, HJ.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994  Scheel, W.: Baugruppentechnologie der Elektronik.  Montage. Verlag Technik, 1999

Course L1555: Reliability of avionics assemblies	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Examination Form</b>	Klausur
Examination duration and scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:  • Survey of the role of electronics in aviation • System levels: From silicon to mechatronic systems • Semiconductor components, assemblies, systems • Challenges of electronic packaging technology (AVT) • System integration in electronics: Requirements for AVT • Methods and techniques of AVT • Error patterns for assemblies and avoidance of errors • Reliability analysis for printed circuit boards (PCBs) • Reliability of Avionics • COTS, ROTS, MOTS and the F <sup>3</sup> I concept • Future challenges for electronics
Literature	- Skript zur Vorlesung Hanke, HJ.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999

Course L0749: Reliability of Aircraft Systems		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
<b>Examination Form</b>	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Functions of reliability and safety (regulations, certification requirements)</li> <li>Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment)</li> <li>Reliability analysis of electrical and mechanical systems</li> </ul>	
Literature	<ul> <li>CS 25.1309</li> <li>SAE ARP 4754</li> <li>SAE ARP 4761</li> </ul>	

Module M1173	3: Applied Statist	ics			
Courses					
Title			Тур	Hrs/wk	СР
Applied Statistics (L15			Lecture Project-/problem-	2	3
Applied Statistics (L15	86)		based Learning	2	2
Applied Statistics (L15)	85)		Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge of statis	stical methods			
Educational Objectives	After taking part success	fully, students h	ave reached the follo	wing learn	ing results
Professional					
Competence Knowledge	Students can explain the statistical methods and the conditions of their use.				
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results				
Personal Competence					
Social Competence	Team Work, joined presentation of results				
Autonomy	To understand and interp	To understand and interpret the question and solve			
<b>Workload in Hours</b>	Independent Study Time	110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement		F <b>orm</b> Written elaborati	<b>Descript</b> on	ion	
Examination	Written exam				
Examination duration and scale	90 minutes, 28 questions	5			
the Following	Mechanical Engineering Compulsory Mechatronics: Specialisat Mechatronics: Specialisat Biomedical Engineering: Product Development, Compulsory Theoretical Mechanical Compulsory Theoretical Mechanical Elective Compulsory	tion System Desition Intelligent S Core qualificatio Materials and Engineering: Te	gn: Elective Compuls ystems and Robotics: n: Compulsory Production: Core chnical Complement	ory Elective ( qualification	Compulsory on: Elective se: Elective

2		
and their		
Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University, Lawrence L. Kupper University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University, Published by Duxbury Press, CB © 1998, ISBN/ISSN: 0-534-20910-6		

Course L1586: App	Course L1586: Applied Statistics		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Michael Morlock		
Language	DE/EN		
Cycle	WiSe		
	The students receive a problem task, which they have to solve in small groups (n=5). They do have to collect their own data and work with them. The results have to be presented in an executive summary at the end of the course.		
Literature	Selbst zu finden		

Course L1585: App	lied Statistics
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	WiSe
Content	The different statistical tests are applied for the solution of realistic problems using actual data sets and the most common used commercial statistical software package (SPSS).
Literature	Student Solutions Manual for Kleinbaum/Kupper/Muller/Nizam's Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University Lawrence L. Kupper University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University, Published by Duxbury Press, Paperbound © 1998, ISBN/ISSN: 0-534-20913-0

Courses					
Title	24)	Тур		Hrs/wk	СР
Materials Physics (L16) Quantum Mechanics a	24) nd Atomistic Materials Modeling (L1672)	Lecture Lecture		2	2
	Physics and Modeling (L2002)	Recitation (small)	Section	2	2
Module Responsible	Prof. Patrick Huber				
Admission Requirements	None				
Recommended Previous Knowledge	Advanced mathematics, physics and natural sciences	chemistry fo	r studen	ts in eng	gineering o
Educational Objectives	After taking part successfully, students	have reached	the follow	ving learn	ing results
Professional Competence					
	The students are able to				
	- explain the fundamentals of condense	d matter phys	ics		
	- describe the fundamentals of the microscopic structure and mechanics, thermodynamics and optics of materials systems.				
Knowledge	- to understand concept and realization as well as to estimate their potential an		methods	in atomis	tic modelin
Skills	<ul> <li>After attending this lecture the students</li> <li>can perform calculations regarding the thermodynamics, mechanics electrical and optical properties of condensed matter systems</li> <li>are able to transfer their knowledge to related technological and scientification fields, e.g. materials design problems.</li> <li>can select appropriate model descriptions for specific materials science problems and are able to further develop simple models.</li> </ul>				
Personal Competence					
Social Competence	The students are able to present so further.	lutions to spe	cialists a	ind to de	velop idea
Autonomy	Students are able to assess their knowldege continuously on their ow by exemplified practice.  The students are able to assess their own strengths and weaknesses and defin tasks independently.				
Workload in Hours	I Independent Study Time 96, Study Time	e in Lecture 84	<u> </u>		
Credit points					
Course achievement	None				
	Written exam				

Examination duration and scale	90 min
Assignment for the Following	Materials Science: Core qualification: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L1624: Mat	erials Physics
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	
Literature	<ul> <li>Für den Elektromagnetismus:</li> <li>Bergmann-Schäfer: "Lehrbuch der Experimentalphysik", Band 2: "Elektromagnetismus", de Gruyter</li> <li>Für die Atomphysik:</li> <li>Haken, Wolf: "Atom- und Quantenphysik", Springer</li> <li>Für die Materialphysik und Elastizität:</li> <li>Hornbogen, Warlimont: "Metallkunde", Springer</li> </ul>

Course L1672: Quantum Mechanics and Atomistic Materials Modeling			
Тур	Lecture		
Hrs/wk			
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Robert Meißner		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>Why atomistic materials modeling</li> <li>Newton's equations of motion and numerical approaches</li> <li>Ergodicity</li> <li>Atomic models</li> <li>Basics of quantum mechanics</li> <li>Atomic &amp; molecular many-electron systems</li> <li>Hartree-Fock and Density-Functional Theory</li> <li>Monte-Carlo Methods</li> <li>Molecular Dynamics Simulations</li> <li>Phase Field Simulations</li> </ul>		
	Begleitliteratur zur Vorlesung (sortiert nach Relevanz):  1. Daan Frenkel & Berend Smit "Understanding Molecular Simulations" 2. Mark E. Tuckerman "Statistical Mechanics: Theory and Molecular Simulations" 3. Andrew R. Leach "Molecular Modelling: Principles and Applications"  Zur Vorbereitung auf den quantenmechanischen Teil der Klausur empfiehlt sich folgende Literatur  1. Regine Freudenstein & Wilhelm Kulisch "Wiley Schnellkurs Quantenmechanik"		

Course L2002: Exercises in Materials Physics and Modeling		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Robert Meißner, Prof. Patrick Huber	
Language	DE	
Cycle	WiSe	
Content		
_	- Daan Frenkel & Berend Smit: Understanding Molecular Simulation from Algorithms to Applications	
Literature	- Rudolf Gross und Achim Marx: Festkörperphysik	
	- Neil Ashcroft and David Mermin: Solid State Physics	

Courses				
Title	nientian tachnalagy in cahin alastronics and	Тур	Hrs/wk	СР
avionics (L1557)	nication technology in cabin electronics and	Lecture	2	2
Computer and commu avionics (L1558)	nication technology in cabin electronics and	Recitation Section (small)	ion <sub>1</sub>	1
Model-Based Systems	Engineering (MBSE) with SysML/UML (L1551)	Project-/problem- based Learning	3	3
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in:  • Mathematics  • Mechanics  • Thermodynamics  • Electrical Engineering  • Control Systems  Previous knowledge in:  • Systems Engineering			
Educational Objectives	After taking part successfully, students h	ave reached the fol	lowing learr	ing results
Professional Competence				
Knowledge	Students are able to: • describe the structure and operation of computer architectures • explain the structure and operation of digital communication Networks • explain architectures of cabin electronics, integrated modular avionics (IMA) and Aircraft Data Communication Network (ADCN) • understand the approach of Model-Based Systems Engineering (MBSE) in the design of hardware and software-based cabin systems			
Skills	Students are able to:  • understand, operate and maintain a Minicomputer  • build up a network communication and communicate with other network participants  • connect a minicomputer with a cabin management system (A380 CIDS) and communicate over a AFDX®-Network  • model system functions by means of formal languages SysML/UML and generate software code from the models  • execute software code on a minicomputer			
Personal Competence				
Social Competence	Students are able to: • elaborate partial results and merge wit	h others to form a c	complete sol	ution
Autonomy	Students are able to: • organize and schedule their practical ta	asks		
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			

Examination duration and scale	120 minutes
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory

Course L1557: Com	puter and communication technology in cabin electronics and avionics
Тур	Lecture
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
	The objective of the lecture with the corresponding exercise is the acquisition of knowledge of computer and communication technology in electronic systems in the cabin and in aircraft. For the system engineer the strong interaction of software, mechanical and electronic system components nowadays requires a basic understanding of cabin electronics and avionics.  The course teaches the basics of design and functionality of computers and data networks. Subsequently it focuses on current principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronics and cabin networks:  History of computer and network technology  Layer model in computer technology  Computer architectures (PC, IPC, Embedded Systems)  BIOS, UEFI and operating system (OS)  Programming languages (machine code and high-level languages)  Applications and Application Programming Interfaces  External interfaces (serial, USB, Ethernet)  Layer model in network technology  Network topologies  Network topologies  Network components  Bus access procedures  Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN)  Cabin electronics and cabin networks
	<ul> <li>Skript zur Vorlesung</li> <li>Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003</li> <li>Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004</li> <li>Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006</li> </ul>

Course L1558: Com	nputer and communication technology in cabin electronics and avionics
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge of computer and communication technology in electronic systems in the cabin and in aircraft. For the system engineer the strong interaction of software, mechanical and electronic system components nowadays requires a basic understanding of cabin electronics and avionics.  The course teaches the basics of design and functionality of computers and data networks. Subsequently it focuses on current principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronics and cabin networks:  History of computer and network technology  Computer architectures (PC, IPC, Embedded Systems)  BIOS, UEFI and operating system (OS)  Programming languages (machine code and high-level languages)  Applications and Application Programming Interfaces  External interfaces (serial, USB, Ethernet)  Layer model in network technology  Network topologies  Network components  Bus access procedures  Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN)  Cabin electronics and cabin networks
Literature	- Skript zur Vorlesung - Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 - Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004 - Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006

Course L1551: Mod	lel-Based Systems Engineering (MBSE) with SysML/UML
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal languages SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Based Systems Engineering (MBSE) on a realistic hardware platform (e.g. Arduino®, Raspberry Pi®):  • What is a model?  • What is Systems Engineering?  • Survey of MBSE methodologies  • The modelling languages SysML /UML  • Tools for MBSE  • Best practices for MBSE  • Requirements specification, functional architecture, specification of a solution  • From model to software code  • Validation and verification: XiL methods  • Accompanying MBSE project
Literature	<ul> <li>Skript zur Vorlesung</li> <li>Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design.</li> <li>Auflage, dpunkt.Verlag, 2008</li> <li>Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering &amp; Tech, 2011</li> </ul>

Courses					
<b>Title</b> 3D Computer Vision (L	0129)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3	
3D Computer Vision (L0130)  Recitation Section 2 (small)			3		
Module Responsible	Prof. Rolf-Rainer Grigat				
Admission Requirements	None				
Recommended Previous Knowledge	<ul> <li>Knowlege of the modules Digital Image Analysis and Pattern Recognition and Data Compression are used in the practical task</li> <li>Linear Algebra (including PCA, SVD), nonlinear optimization (Levenberg-Marquardt), basics of stochastics and basics of Matlab are required and cannot be explained in detail during the lecture.</li> </ul>				
Educational Objectives	After taking part successfully, studer	ts have reached	the following learr	ning results	
Professional Competence					
Knowledge	Students can explain and describe th	e field of project	ive geometry.		
Skills	<ul> <li>Implementing an exemplary 3</li> <li>Using highly sophisticated me</li> <li>Identifying problems and</li> <li>Developing and implementing</li> <li>With assistance from the teacher stusubject areas (modules)</li> <li>Digital Image Analysis</li> <li>Pattern Recognition and Data and</li> <li>3D Computer Vision</li> <li>in practical assignments.</li> </ul>	thods and proced creative solution Idents are able to	dures of the subjec		
Personal Competence					
Social Competence	Students can collaborate in a small to system to reconstruct a three-diment				
	Students are able to solve simple contents of the lectures and the exer		dently with refer	ence to th	
Autonomy	Students are able to solve detailed problems independently with the aid of th tutorial's programming task.				
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 5	56		
Credit points					
Course achievement	None				
Examination	Written exam				
Examination duration and	60 Minutes, Content of Lecture and n	naterials in Studl	P		

	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Software and Signal Processing: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective
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Assignment for	
the Following	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
Curricula	Microelectronics and Microsystems: Specialisation Communication and Signal
	Processing: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science:
	Elective Compulsory

Course L0129: 3D	Computer Vision
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Rolf-Rainer Grigat
Language	EN
Cycle	WiSe
Content	<ul> <li>Projective Geometry and Transformations in 2D und 3D in homogeneous coordinates</li> <li>Projection matrix, calibration</li> <li>Epipolar Geometry, fundamental and essential matrices, weak calibration, 5 point algorithm</li> <li>Homographies 2D and 3D</li> <li>Trifocal Tensor</li> <li>Correspondence search</li> </ul>
Literature	<ul> <li>Skriptum Grigat/Wenzel</li> <li>Hartley, Zisserman: Multiple View Geometry in Computer Vision. Cambridge 2003.</li> </ul>

Course L0130: 3D Computer Vision		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Rolf-Rainer Grigat	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0549	9: Scientific Computing and	Accuracy	/		
Courses					
<b>Title</b> Verification Methods (L	_0122)	<b>Typ</b> Lecture Recitation	Soction	Hrs/wk	<b>CP</b> 3
Verification Methods (L	.1208)	(small)	Section	12	3
Module Responsible	Prof. Siegfried Rump				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge in numerics				
Educational Objectives	After taking part successfully, students	have reached	the follo	wing learn	ing results
Professional Competence					
Knowledge	The students have deeper knowledge of numerical and seminumerical methods with the goal to compute principally exact and accurate error bounds. For several fundamental problems they know algorithms with the verification of the correctness of the computed result.				
Skills	The students can devise algorithms for several basic problems which compute rigorous error bounds for the solution and analyze the sensitivity with respect to variation of the input data as well.				
Personal Competence					
Social Competence	The students have the skills small groups and to prese appropriate manner.		•		
Autonomy	The students are able to retri the given literature and to cor lecture. Throughout the lectu and knowledge on the bas questions providing an aid to	mbine ther ire they ca is of give	n with an che en exe	the top ck their ercises	ics of the abilities and tes
Workload in Hours	Independent Study Time 124, Study Tim	ne in Lecture !	56		
Credit points					
Course achievement	None				
Examination Examination duration and scale					
	Theoretical Mechanical Engineering: Tompulsory	Technical Con	nplement	ary Cour	se: Elective

Course L0122: Veri	fication Methods
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe
Content	<ul> <li>Fast and accurate interval arithmetic</li> <li>Error-free transformations</li> <li>Verification methods for linear and nonlinear systems</li> <li>Verification methods for finite integrals</li> <li>Treatment of multiple zeros</li> <li>Automatic differentiation</li> <li>Implementation in Matlab/INTLAB</li> </ul>
	<ul> <li>Practical applications</li> <li>Neumaier: Interval Methods for Systems of Equations. In: Encyclopedia of Mathematics and its Applications. Cambridge University Press, 1990</li> </ul>
Literature	S.M. Rump. Verification methods: Rigorous results using floating-point arithmetic. Acta Numerica, 19:287-449, 2010.

Course L1208: Verification Methods		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Siegfried Rump	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0629	9: Intelligent Autor	nomous A	gents and	d Cogi	nitive I	Robotics
Courses						
_	s Agents and Cognitive Roboti		<b>Typ</b> Lecture Recitation	Section	Hrs/wk 2	<b>CP</b> 4
Intelligent Autonomou	s Agents and Cognitive Roboti	cs (L0512)	(small)	Section	2	2
Responsible	Rainer Marrone					
Admission Requirements	None					
Recommended Previous Knowledge	Vectors, matrices, Calculus	3				
Educational Objectives	After taking part successfu	lly, students h	ave reached	the follow	ving learn	ing results
Professional Competence						
Knowledge	behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.					
Skills	Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilibria states,e.g., Nash equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results.					
Personal Competence						
Social Competence	Students are able to di communicate in English	scuss their s	solutions to	problem	s with o	thers. The
Autonomy	Students are able of check varaints of concrete proble		erstanding of	complex	c concept	s by solving
Workload in Hours	Independent Study Time 12	24, Study Time	e in Lecture 5	6		_
Credit points						
Course						

achievement	None
Examination	Written exam
Examination duration and scale	90 minutes
	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

Lecture		
2		
4		
Independent Study Time 92, Study Time in Lecture 28		
Rainer Marrone		
EN		
WiSe		
<ul> <li>Definition of agents, rational behavior, goals, utilities, environment types</li> <li>Adversarial agent cooperation:         Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of chance</li> <li>Uncertainty:         Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity, independence assumptions, naive Bayes, conditional independence assumptions</li> <li>Bayesian networks:         Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived).</li> <li>Probabilistic reasoning over time:         Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations</li> <li>Decision making under uncertainty:         Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio         Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs         Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks</li> <li>Simultaneous Localization and Mapping</li> <li>Planning</li> <li>Game theory (Golden Balls: Split or Share)         Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium</li> <li>Social Choice         Voting protocols, preferences, paradoxes, Arrow's Theorem,</li> <li>Mechanism Design</li> <li>Fundamentals, dominant strategy impl</li></ul>		
<ol> <li>Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17</li> <li>Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005</li> <li>Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009</li> </ol>		

Course L0512: Intelligent Autonomous Agents and Cognitive Robotics		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Rainer Marrone	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses				
Title	15: " 15" (10446)	Тур	Hrs/wk	СР
	ng and Digital Filters (L0446)	Lecture Recitation	3 Section <sub>2</sub>	4
Digital Signal Processi	ng and Digital Filters (L0447)	(large)	2	2
Module Responsible	Prof. Gerhard Bauch			
Admission Requirements	INODE			
Recommended Previous Knowledge	<ul> <li>Mathematics 1-3</li> <li>Signals and Systems</li> <li>Fundamentals of signal and system theory as well as random processes.</li> <li>Fundamentals of spectral transforms (Fourier series, Fourier transform, Laplace transform)</li> </ul>			
Educational Objectives	After taking part successfully, stude	nts have reached t	the following learr	ing results
Professional Competence				
Knowledge	The students know and understand basic algorithms of digital signal processing They are familiar with the spectral transforms of discrete-time signals and are able to describe and analyse signals and systems in time and image domain. They know basic structures of digital filters and can identify and assess important properties including stability. They are aware of the effects caused by quantization of filter coefficients and signals. They are familiar with the basics of adaptive filters. They can perform traditional and parametric methods of spectrum estimation, also taking a limited observation window into account.			
Skills	The students are able to apply methods of digital signal processing to new problems. They can choose and parameterize suitable filter striuctures. In particular the can design adaptive filters according to the minimum mean squared error			
Personal Competence				
Social Competence	The students can jointly solve speci	ic problems.		
Autonomy	The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems, software tools, clicker system.			
Workload in Hours	Independent Study Time 110, Study	Time in Lecture 7	0	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
	Electrical Engineering: Specialisat Elective Compulsory Computational Science and Engin Elective Compulsory Information and Communication Sy Focus Signal Processing: Elective Co	eering: Specialisa	tion II. Engineeri	ng Science

	Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory
Assignment for	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
the Following	Microelectronics and Microsystems: Specialisation Communication and Signal
Curricula	Processing: Elective Compulsory
	Microelectronics and Microsystems: Specialisation Communication and Signal
	Processing: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science:
	Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science:
	Elective Compulsory

Course L0446: Digi	tal Signal Processing and Digital Filters		
Тур	Lecture		
Hrs/wk	3		
СР	4		
	Independent Study Time 78, Study Time in Lecture 42		
	Prof. Gerhard Bauch		
Language Cycle			
Content	<ul> <li>Transforms of discrete-time signals:         <ul> <li>Discrete-time Fourier Transform (DTFT)</li> <li>Discrete Fourier-Transform (DFT), Fast Fourier Transform (FFT)</li> <li>Z-Transform</li> </ul> </li> <li>Correspondence of continuous-time and discrete-time signals, sampling, sampling theorem</li> <li>Fast convolution, Overlap-Add-Method, Overlap-Save-Method</li> <li>Fundamental structures and basic types of digital filters</li> <li>Characterization of digital filters using pole-zero plots, important properties of digital filters</li> <li>Quantization effects</li> <li>Design of linear-phase filters</li> <li>Fundamentals of stochastic signal processing and adaptive filters         <ul> <li>MMSE criterion</li> <li>Wiener Filter</li> <li>LMS- and RLS-algorithm</li> </ul> </li> <li>Traditional and parametric methods of spectrum estimation</li> </ul>		
Literature	<ul> <li>KD. Kammeyer, K. Kroschel: Digitale Signalverarbeitung. Vieweg Teubner.</li> <li>V. Oppenheim, R. W. Schafer, J. R. Buck: Zeitdiskrete Signalverarbeitung. Pearson StudiumA. V.</li> <li>W. Hess: Digitale Filter. Teubner.</li> <li>Oppenheim, R. W. Schafer: Digital signal processing. Prentice Hall.</li> <li>S. Haykin: Adaptive flter theory.</li> <li>L. B. Jackson: Digital filters and signal processing. Kluwer.</li> <li>T.W. Parks, C.S. Burrus: Digital filter design. Wiley.</li> </ul>		

Course L0447: Digital Signal Processing and Digital Filters		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Gerhard Bauch	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0746: Microsystem Engineering					
Courses					
Title Microsystem Engineering (L0680) Microsystem Engineering (L0682)			<b>Typ</b> Lecture Project-/problem-	Hrs/wk 2 2	<b>CP</b> 4
			based Learning		
Module Responsible	Prof. Manfred Kasper				
Admission Requirements	LNODE				
Recommended Previous Knowledge	Basic courses in physics, mathematics and electric engineering				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					(145146
Knowledge	The students know about the most important technologies and materials of MEMS well as their applications in sensors and actuators.				
Skills	Students are able to analyze and describe the functional behaviour of MEN components and to evaluate the potential of microsystems.				
Personal Competence		-l : <b>:</b> : l. l			
Social Competence	Students are able to solve specific problems alone or in a group and to present the results accordingly.				
Autonomy	Students are able to acquire particular knowledge using specialized literature and integrate and associate this knowledge with other fields.				
	Independent Study Tim	ne 124, Study Tim	e in Lecture 56		
Credit points	6				
Course achievement	CompulsorBonus No 10 %	<b>Form</b> Presentation	Descri	ption	
Examination	Written exam				
Examination duration and scale	2h				
Assignment for the Following Curricula	Compulsory				
	Biomedical Engineering: Specialisation Medical Technology and Control Theory Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration Elective Compulsory Microelectronics and Microsystems: Core qualification: Elective Compulsory				

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L0680: Microsystem Engineering			
Тур	Lecture		
Hrs/wk	2		
СР	4		
	ndependent Study Time 92, Study Time in Lecture 28		
	Prof. Manfred Kasper		
Language			
Cycle			
	Object and goal of MEMS		
	Scaling Rules		
	Lithography		
	Film deposition		
	Structuring and etching		
	Energy conversion and force generation		
	Electromagnetic Actuators		
	Reluctance motors		
Content	Piezoelectric actuators, bi-metal-actuator		
	Transducer principles		
	Signal detection and signal processing		
	Mechanical and physical sensors		
	Acceleration sensor, pressure sensor		
	Sensor arrays		
	System integration		
	Yield, test and reliability		
	M. Kasper: Mikrosystementwurf, Springer (2000)		
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press (1997)		

Course L0682: Microsystem Engineering	
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Manfred Kasper
Language	EN
Cycle	WiSe
	Examples of MEMS components
	Layout consideration
Content	Electric, thermal and mechanical behaviour
	Design aspects
Literature	Wird in der Veranstaltung bekannt gegeben

Module MU92.	1: Electronic Circuits for	месісаі Аррііс	cations	
Courses				
<b>Title</b> Electronic Circuits for I	Medical Applications (L0696)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3
Electronic Circuits for I	Medical Applications (L1056)	Recitation S (small)	Section 1	2
Electronic Circuits for I	Medical Applications (L1408)	Practical Course	1	1
itesponsible				
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of electrical enginee	ering		
Educational Objectives	After taking part successfully, stud	ents have reached the	e following lear	ning results
Professional Competence				
Knowledge	<ul> <li>Students can explain the bacentral nervous system</li> <li>Students are able to explain propagation along an axon</li> <li>Students can exemplify the devices</li> <li>Students can describe the sapplications</li> <li>Students can explain the fur</li> <li>Students are able to discuss and artificial eyes</li> </ul>	communication betw pecial features of low-	an action pote reen neurons a noise amplifier e. g. an artificia	ntial and ind electron s for medical hand
Skills	<ul> <li>Students can calculate the potential</li> <li>Students can give scenario power signal acquisition.</li> <li>Students can develop the b</li> <li>Students can define the bui eye.</li> </ul>	s for further improve	ment of low-no	ise and lov
Personal Competence				
Social Competence	<ul> <li>Students are trained to solve teams together with experts</li> <li>Students are able to recogn for assistance to the right till</li> <li>Students can document the results in a way that others</li> </ul>	with different professize their specific limit ne. ir work in a clear mar	sional backgrou ations, so that nner and comm	nd. they can as unicate the
	<ul> <li>Students are able to realist define actions for improvem</li> <li>Students can break down</li> </ul>	ents when necessary.		

Autonomy	<ul> <li>schedule their work in a realistic way.</li> <li>Students can handle the complex data structures of bioelectrical experiments without needing support.</li> <li>Students are able to act in a responsible manner in all cases and situations of experimental work.</li> </ul>	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points	6	
	CompulsorBonus Form Description	
Course achievement	Yes None Subject theoretical and practical work	
	No None Excercises	
Examination	Written exam	
Examination duration and scale		
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory	

Course L0696: Elec	tronic Circuits for Medical Applications
Тур	Lecture
Hrs/wk	2
СР	3
	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	
Cycle	WiSe
Content	<ul> <li>Market for medical instruments</li> <li>Membrane potential, action potential, sodium-potassium pump</li> <li>Information transfer by the central nervous system</li> <li>Interface tissue - electrode</li> <li>Amplifiers for medical applications, analog-digital converters</li> <li>Examples for electronic implants</li> <li>Artificial eye, cochlea implant</li> </ul>
Literature	Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)  Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007  Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm  Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Course L1056: Electronic Circuits for Medical Applications	
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1408: Elec	tronic Circuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul> <li>Market for medical instruments</li> <li>Membrane potential, action potential, sodium-potassium pump</li> <li>Information transfer by the central nervous system</li> <li>Interface tissue - electrode</li> <li>Amplifiers for medical applications, analog-digital converters</li> <li>Examples for electronic implants</li> <li>Artificial eye, cochlea implant</li> </ul>
Literature	Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007 Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Module M051	5: Energy Information Syste	ms and Ele	ectromobili	ty
Courses				
	Electrical Power Systems II: Operation and Information Systems of Electrical Power Grids (L1696)		<b>Hrs/wk</b> 2 2	<b>CP</b> 4 2
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students h	nave reached th	e following learn	ing results
Professional Competence	Students are able to give an overview o			
Knowledge	of renewable energies. They can explain in detail the possibilities for the integratio of renewable energy systems into the existing grid, the electrical storag possibilities and the electric power transmission and distribution, and ca take critically a stand on it.			cal storage
Skills	With completion of this module the students are able to apply the acquired skills in applications of the design, integration, development of renewable energy systems and to assess the results.			
Personal Competence	The students can participate in spe			discussions,
Social Competence	advance ideas and represent their own v			
Autonomy	Students can independently tap knowled	ige of the emph	asis of the lectur	es.
	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and scale				
the Following	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory			

Course L1696: Elec Power Grids	ctrical Power Systems II: Operation and Information Systems of Electrical
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	<ul> <li>steaedy-state modelling of electric power systems         <ul> <li>conventional components</li> <li>Flexible AC Transmission Systems (FACTS) and HVDC</li> <li>grid modelling</li> </ul> </li> <li>grid operation         <ul> <li>electric power supply processes</li> <li>grid and power system management</li> <li>grid provision</li> </ul> </li> <li>grid control systems         <ul> <li>information and communication systems for power system management</li> <li>IT architectures of bay-, substation and network control level</li> <li>IT integration (energy market / supply shortfall management / asset management)</li> <li>future trends of process control technology</li> <li>smart grids</li> </ul> </li> <li>functions and steady-state computations for power system operation and plannung         <ul> <li>load-flow calculations</li> <li>sensitivity analysis and power flow control</li> <li>power system optimization</li> <li>short-circuit calculation</li> <li>asymmetric failure calculation</li> <li>asymmetric components</li> <li>calculation of asymmetric failures</li> </ul> </li> </ul>
Literature	E. Handschin: Elektrische Energieübertragungssysteme, Hüthig Verlag B. R. Oswald: Berechnung von Drehstromnetzen, Springer-Vieweg Verlag V. Crastan: Elektrische Energieversorgung Bd. 1 & 3, Springer Verlag EG. Tietze: Netzleittechnik Bd. 1 & 2, VDE-Verlag

Course L1833: Electro mobility		
Тур	Lecture	
Hrs/wk	2	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Dr. Klaus Bonhoff	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Vehicle Integration</li> <li>Energy consumption of electric cars</li> <li>Battery life</li> <li>Charging Infrastructure</li> <li>Electric road transport</li> <li>Electric public transport</li> <li>Battery Safety</li> </ul>	
Literature	Vorlesungsunterlagen/ lecture material	
Literature	vonesungsuntenagen/ lecture material	

## Module M1148: Selected topics in Naval Architecture and Ocean Engineering

Courses				
Title		Тур	Hrs/wk	СР
Outfitting and Operation of Special Purpose Offshore Ships (L1896)		Lecture	2	3
Design of Underwater	Vessels (L0670) hods for the simulation of free surface flows	Lecture	2	3
(L2066)	indus for the simulation of free surface flows	Lecture	2	3
Modeling and Simulation	on of Maritime Systems (L2013)	Project-/problem-	2	3
Offshore Wind Parks (L	-	based Learning Lecture	2	3
Ship Acoustics (L1605)		Lecture	2	3
Ship Dynamics (L0352		Lecture	2	3
Selected Topics of Exp (L0240)	erimental and Theoretical Fluiddynamics	Lecture	2	3
	d Fluid Mechanics of Sailing Ships (L0873)	Lecture	2	3
Technology of Naval S	urface Vessels (L0765)	Lecture	2	3
Module	Prof. Sören Ehlers			
Admission Requirements	None			
Recommended				
Previous Knowledge				
Educational				
Objectives	After taking part successfully, students h	ave reached the fol	llowing learn	ing results
Professional Competence				
Knowledge	<ul> <li>Students are able to find their way through selected special areas within naval architecture and ocean engineering</li> <li>Students are able to explain basic models and procedures in selected special areas.</li> <li>Students are able to interrelate scientific and technical knowledge.</li> </ul>			
Skills	Students are able to apply basic methods in selected areas of ship and ocean engineering.			
Personal Competence				
Social Competence	The students are able to communicate a in the shipbuilding and component suppl		rofessional	environment
Autonomy	Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.			
<b>Workload in Hours</b>	Depends on choice of courses			
Credit points	6			
the Following	Naval Architecture and Ocean Engineerir Theoretical Mechanical Engineering: Sp Compulsory Theoretical Mechanical Engineering: To Compulsory	ecialisation Maritin	ne Technolo	gy: Elective

Course L1896: Out	fitting and Operation of Special Purpose Offshore Ships
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Examination Form</b>	Mündliche Prüfung
Examination duration and scale	
Lecturer	Dr. Hendrik Vorhölter
Language	DE
Cycle	SoSe
Content	The lecture is separated into two parts. In the first part some basic skills necessary for the design of offshore vessels and their equipment will be repeated and where necessary deepened. In particular, the specialties which are common for the majority of offshore vessels will be addressed: rules and regulations, determination of operational limits as well as mooring and dynamic positioning.  In the second part of the lecture single types of special offshore vessels and their equipment and outfitting will be addressed. For each type the specific requirements on design and operation will be discussed. Furthermore, the students shall be engaged with the preparation of short presentation about the specific ship types as incentive for the respective unit. In particular, it is planned to discuss the following ship types in the lecture:  - Anchor handling and plattform supply vessels  - Cable -and pile lay vessels  - Jack-up vessels  - Heavy lift and offshore construction vessels  - Dredgers and rock dumping vessels  - Diving support vessels
Literature	Chakrabarti, S. (2005): Handbook of Offshore Engineering. Elsevier. Amsterdam, London  Volker Patzold (2008): Der Nassabbau. Springer. Berlin  Milwee, W. (1996): Modern Marine Salvage. Md Cornell Maritime Press. Centreville.  DNVGL-ST-N001 "Marine Operations and Marin Warranty"  IMCA M 103 "The Design and Operation of Dynamically Positioned Vessels" 2007-12  IMCA M 182 "The Safe Operation of Dynamically Positioned Offshore Supply Vessels" 2006-03  IMCA M 187 "Lifting Operations" 2007-10  IMCA SEL 185 "Transfer of Personnel to and from Offshore Vessels" 2010-03

Course L0670: Des	ign of Underwater Vessels
Тур	Lecture
Hrs/wk	
СР	
Workload in Hours  Examination Form	Independent Study Time 62, Study Time in Lecture 28
Examination Form duration and scale	
	Peter Hauschildt
Language	
Cycle	The lectures will give an overview about the design of underwater vessels. The
	Topics are:  1.) Special requirements on the design of modern, konventional submarines  2.) Design history
	3.) Generals description of submarines
	4.) Civil submersibles
	5.) Diving, trim, stability
	6.) Rudders and Propulsion systems
	7.) Air Independent propulsion
	8.) Signatures
Content	9.) Hydrodynamics and CFD
	10.) Weapon- and combatmangementsystems
	11.) Safety and rescue
	12.) Fatigue and shock
	13.) Ships technical systems
	14.) Electricals Systems and automation
	15.) Logisics
	16.) Accomodation
	Some of the lectures will be Hheld in form of a excursion to ThyssenKrupp Marine Systems in Kiel
Literature	Gabler, Ubootsbau

Course L2066: Lattice-Boltzmann methods for the simulation of free surface flows		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
<b>Examination Form</b>	Mündliche Prüfung	
Examination duration and scale	30 min	
Lecturer	Dr. Christian F. Janßen	
Language	DE/EN	
Cycle	WiSe	
Content	This lecture addresses Lattice Boltzmann Methods for the simulation of free surface flows. After an introduction to the basic concepts of kinetic methods (LGCAs, LBM,), recent LBM extensions for the simulation of free-surface flows are discussed. Parallel to the lecture, selected maritime free-surface flow problems are to be solved numerically.	
Literature	Krüger et al., "The Lattice Boltzmann Method - Principles and Practice", Springer Zhou, "Lattice Boltzmann Methods for Shallow Water Flows", Springer Janßen, "Kinetic approaches for the simulation of non-linear free surface flow problems in civil and environmental engineering", PhD thesis, TU Braunschweig, 2010.	

Course L2013: Modeling and Simulation of Maritime Systems		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
<b>Examination Form</b>	Mündliche Prüfung	
Examination duration and scale		
Lecturer	Dr. Christian F. Janßen	
Language	DE/EN	
Cycle	SoSe	
Content	In the scope of this lecture, students learn to model and solve selected maritime problems with the help of numerical programs and scripts.  First, basic concepts of computational modeling are explained, from the physical modeling and discretization to the implementation and actual numerical solution of the problem. Then, available tools for the implementation and solution process are discussed, including high-level compiled and interpreted programming languages and computer algebra systems (e.g., Python; Matlab, Maple). In the second half of the class, selected maritime problems will be discussed and subsequently solved numerically by the students.	
Literature	"Introduction to Computational Modeling Using C and Open-Source Tools" (J.M. Garrido, Chapman and Hall); "Introduction to Computational Models with Python" (J.M. Garrido, Chapman and Hall); "Programming Fundamentals" (MATLAB Handbook, MathWorks);	

Course L0072: Offshore Wind Parks		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
<b>Examination Form</b>	Mündliche Prüfung	
Examination duration and scale		
Lecturer	Dr. Alexander Mitzlaff	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Nonlinear Waves: Stability, pattern formation, solitary states</li> <li>Bottom Boundary layers: wave boundary layers, scour, stability of marine slopes</li> <li>Ice-structure interaction</li> <li>Wave and tidal current energy conversion</li> </ul>	
Literature	<ul> <li>Chakrabarti, S., Handbook of Offshore Engineering, vol. I&amp;II, Elsevier 2005.</li> <li>Mc Cormick, M.E., Ocean Wave Energy Conversion, Dover 2007.</li> <li>Infeld, E., Rowlands, G., Nonlinear Waves, Solitons and Chaos, Cambridge 2000.</li> <li>Johnson, R.S., A Modern Introduction to the Mathematical Theory of Water Waves, Cambridge 1997.</li> <li>Lykousis, V. et al., Submarine Mass Movements and Their Consequences, Springer 2007.</li> <li>Nielsen, P., Coastal Bottom Boundary Layers and Sediment Transport, World Scientific 2005.</li> <li>Research Articles.</li> </ul>	

Course L1605: Ship Acoustics		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
<b>Examination Form</b>	Mündliche Prüfung	
Examination duration and scale	30 min	
Lecturer	Dr. Dietrich Wittekind	
Language	DE	
Cycle	SoSe	
Content		
Literature		

Course L0352: Ship Dynamics	
Тур	Lecture
Hrs/wk	2

Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination and scale			
Lecturer	Prof. Moustafa Abdel-Maksoud		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>Equations of motion</li> <li>Hydrodynamic forces and moments</li> <li>Linear equations and their solutions</li> <li>Full-scale trials for evaluating the maneuvering performance</li> <li>Regulations for maneuverability</li> <li>Rudder</li> </ul> Seakeeping <ul> <li>Representation of harmonic processes</li> <li>Motions of a rigid ship in regular waves</li> <li>Flow forces on ship cross sections</li> <li>Strip method</li> <li>Consequences induced by ship motion in regular waves</li> <li>Behavior of ships in a stationary sea state</li> <li>Long-term distribution of seaway influences</li> </ul>		
Literature	<ul> <li>Abdel-Maksoud, M., Schiffsdynamik, Vorlesungsskript, Institut für Fluiddynamik und Schiffstheorie, Technische Universität Hamburg-Harburg, 2014</li> <li>Abdel-Maksoud, M., Ship Dynamics, Lecture notes, Institute for Fluid Dynamic and Ship Theory, Hamburg University of Technology, 2014</li> <li>Bertram, V., Practical Ship Design Hydrodynamics, Butterworth-Heinemann, Linacre House - Jordan Hill, Oxford, United Kingdom, 2000</li> <li>Bhattacharyya, R., Dynamics of Marine Vehicles, John Wiley &amp; Sons, Canada,1978</li> <li>Brix, J. (ed.), Manoeuvring Technical Manual, Seehafen-Verlag, Hamburg, 1993</li> <li>Claus, G., Lehmann, E., Östergaard, C). Offshore Structures, I+II, Springer-Verlag. Berlin Heidelberg, Deutschland, 1992</li> <li>Faltinsen, O. M., Sea Loads on Ships and Offshore Structures, Cambridge University Press, United Kingdom, 1990</li> <li>Handbuch der Werften, Deutschland, 1986</li> <li>Jensen, J. J., Load and Global Response of Ships, Elsevier Science, Oxford, United Kingdom, 2001</li> <li>Lewis, Edward V. (ed.), Principles of Naval Architecture - Motion in Waves and Controllability, Society of Naval Architects and Marine Engineers, Jersey City, NJ, 1989</li> <li>Lewandowski, E. M., The Dynamics of Marine Craft: Maneuvering and Seakeeping, World Scientific, USA, 2004</li> <li>Lloyd, A., Ship Behaviour in Rough Weather, Gosport, Chichester, Sussex, United Kingdom, 1998</li> </ul>		

Course L0240: Selected Topics of Experimental and Theoretical Fluiddynamics			
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
<b>Examination Form</b>	Mündliche Prüfung		
Examination duration and scale			
Lecturer	Prof. Thomas Rung		
Language	DE		
Cycle	WiSe		
Content	Will be announced at the beginning of the lecture. Exemplary topics are  1. methods and procedures from experimental fluid mechanics 2. rational Approaches towards flow physics modelling 3. selected topics of theoretical computation fluid dynamics 4. turbulent flows		
Literature	Wird in der Veranstaltung bekannt gegeben. To be announced during the lecture.		

Course L0873: Tecl	hnical Elements and Fluid Mechanics of Sailing Ships		
Тур	Lecture		
Hrs/wk	2		
СР			
	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Mündliche Prüfung		
Examination duration and scale	30 min		
	Prof. Thomas Rung, Peter Schenzle		
Language			
Cycle			
	Principles of Sailing Mechanics:		
	- Sailing: Propulsion from relative motion		
	- Lifting foils: Sails, wings, rudders, fins, keels		
	- Wind climate: global, seasonal, meteorological, local		
	- Aerodynamics of sails and sailing rigs		
	- Hydrodynamics of Hulls and fins		
	Technical Elements of Sailing:		
	- Traditional and modern sail types		
Content	- Modern and unconventional wind propulsors		
	- Hull forms and keel-rudder-configurations		
	- Sailing performance Prediction (VPP)		
	- Auxiliary wind propulsion (motor-sailing)		
	Configuration of Sailing Ships:		
	- Balancing hull and sailing rig		
	- Sailing-boats and -yachts		
	- Traditional Tall Sailing Ships		
	- Modern Wind-Ships		
Literature	<ul> <li>Vorlesungs-Manuskript mit Literatur-Liste: Verteilt zur Vorlesung</li> <li>B. Wagner: Fahrtgeschwindigkeitsberechnung für Segelschiffe, IfS-Rep. 132, 1967</li> <li>B. Wagner: Sailing Ship Research at the Hamburg University, IfS-Script 2249, 1976</li> <li>A.R. Claughton et al.: Sailing Yacht Design 1&amp;2, University of Southampton, 1998</li> <li>L. Larsson, R.E. Eliasson: Principles of Yacht Design, Adlard Coles Nautical, London, 2000</li> </ul>		
	- K. Hochkirch: Entwicklung einer Messyacht, Diss. TU Berlin, 2000		

Course L0765: Technology of Naval Surface Vessels		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
<b>Examination Form</b>	Mündliche Prüfung	
Examination duration and scale		
Lecturer	Dr. Martin Schöttelndreyer	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Operational scenarios, tasks, capabilities, requirements</li> <li>Product and process models, rules and regulations</li> <li>Survivability: threats, signatures, counter measures</li> <li>Design characteristics</li> <li>Energy and propulsion systems</li> <li>Command and combat systems</li> <li>Vulnerability: residual strength, residual functionality</li> </ul>	
Literature	Th. Christensen, HD. Ehrenberg, H. Götte, J. Wessel: Entwurf von Fregatten und Korvetten, in: H. Keil (Hrsg.), Handbuch der Werften, Bd. XXV, Schiffahrts-Verlag "Hansa" C. Schroedter & Co., Hamburg (2000)  16th International Ship and Offshore Structures Congress: Committee V.5 - Naval Ship Design (2006)  P. G. Gates: Surface Warships - An Introduction to Design Principles, Brassey's Defence Publishers, London (1987)	

Module M0511: Electricity Generation from Wind and Hydro Power				
Courses				
Title		Тур	Hrs/wk	СР
Sustainability Manager	ment (L0007)	Lecture	2	1
Hydro Power Use (L00:		Lecture	1	1
Wind Turbine Plants (L	-	Lecture	2	3
Wind Energy Use - Foc	us Offshore (L0012)	Lecture	1	1
Module Responsible	Dr. Isabel Höfer			
Admission Requirements	None			
	Module: Technical Thermodynan	nics I,		
Recommended	Module: Technical Thermodynan	nics II.		
Previous Knowledge	-			
5	Module: Fundamentals of Fluid M	Techanics		
Educational Objectives	After taking part successfully, st	udents have reached th	e following learn	ing results
Professional				
Competence				
Knowledge	By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe.  Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice.			
Skills	Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.			
Personal				
Competence				
Social Competence	Students can discuss scientific seminar.	tasks subjet-specificly a	nd multidisciplin	nary within a
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2.5 hours written exam + Prense	entation in sustainability	management	

Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Renewable Energies: Core qualification: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory Water and Environmental Engineering: Specialisation Environment: Compulsory Water and Environmental Engineering: Specialisation Cities: Elective Compulsory
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and dimensions of sustainability. This content of the course is based on the foundations of environmental assessment; therefore the previous attendance of the lecture environmental assessment is recommended. Various valuation approaches for assessing environmental, economic and social aspects are presented. Their application and use for a sustainability management's discussion is explained by means of short technology examples and is later comprehensively presented through case examples.  • Introduction to the topic of sustainability • Dimensions of sustainability:	Course L0007: Sustainability Management		
Morkload in Hours   Independent Study Time 2, Study Time in Lecture 28	Тур	Lecture	
Lecturer   Dr. Anne Rödl	Hrs/wk	2	
Lecturer Dr. Anne Rödl  Language DE  Cycle WiSe  The lecture sustainability management provide an insight into the various aspects and dimensions of sustainability. This content of the course is based on the foundations of environmental assessment; therefore the previous attendance of the lecture environmental assessment is recommended. Various valuation approaches for assessing environmental, economic and social aspects are presented. Their application and use for a sustainability management's discussion is explained by means of short technology examples and is later comprehensively presented through case examples.  • Introduction to the topic of sustainability • Dimensions of sustainability: • ecology • economics • social • Transition from the environmental assessment for sustainability managemen • Case Studies • Excursion  Objective: The aim of the course is to learn methods for the assessment or sustainability aspects and apply for sustainability management.  Engelfried, J. (2011) Nachhaltiges Umweltmanagement. München: Oldenbourg Verlag. 2. Auflage  Corsten H., Roth S. (Hrsg.) (2011) Nachhaltigkeit - Unternehmerisches Handeln in	СР	1	
Cycle   WiSe	<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28	
The lecture sustainability management provide an insight into the various aspects and dimensions of sustainability. This content of the course is based on the foundations of environmental assessment; therefore the previous attendance of the lecture environmental assessment is recommended. Various valuation approaches for assessing environmental, economic and social aspects are presented. Their application and use for a sustainability management's discussion is explained by means of short technology examples and is later comprehensively presented through case examples.  • Introduction to the topic of sustainability • Dimensions of sustainability: • ecology • economics • social • Transition from the environmental assessment for sustainability management • Case Studies • Excursion  Objective: The aim of the course is to learn methods for the assessment or sustainability aspects and apply for sustainability management.  Engelfried, J. (2011) Nachhaltiges Umweltmanagement. München: Oldenbourg Verlag. 2. Auflage  Corsten H., Roth S. (Hrsg.) (2011) Nachhaltigkeit - Unternehmerisches Handeln in	Lecturer	Dr. Anne Rödl	
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Verlag. 2. Auflage  Corsten H., Roth S. (Hrsg.) (2011) Nachhaltigkeit - Unternehmerisches Handeln in		<ul> <li>Introduction to the topic of sustainability</li> <li>Dimensions of sustainability:         <ul> <li>ecology</li> <li>economics</li> <li>social</li> </ul> </li> <li>Transition from the environmental assessment for sustainability management</li> <li>Case Studies</li> <li>Excursion</li> <li>Objective: The aim of the course is to learn methods for the assessment of</li> </ul>	
	Literature	Corsten H., Roth S. (Hrsg.) (2011) Nachhaltigkeit - Unternehmerisches Handeln in	

Course L0013: Hyd	ro Power Use
Тур	Lecture
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Stephan Heimerl
Language	DE
Cycle	SoSe
Content	<ul> <li>Introduction, importance of water power in the national and global context</li> <li>Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies</li> <li>Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems</li> <li>Construction of hydroelectric power plants: description of the individual components and their technical system interaction</li> <li>Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc.</li> <li>Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection</li> <li>Hydropower and the Environment</li> <li>Examples from practice</li> </ul>
Literature	<ul> <li>Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage</li> <li>Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage</li> <li>Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage</li> <li>von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage</li> <li>Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006</li> </ul>

Course L0011: Wind Turbine Plants				
Тур	Lecture			
Hrs/wk	2			
СР	3			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Dr. Rudolf Zellermann			
Language	DE			
Cycle	SoSe			
Content	<ul> <li>Historical development</li> <li>Wind: origins, geographic and temporal distribution, locations</li> <li>Power coefficient, rotor thrust</li> <li>Aerodynamics of the rotor</li> <li>Operating performance</li> <li>Power limitation, partial load, pitch and stall control</li> <li>Plant selection, yield prediction, economy</li> <li>Excursion</li> </ul>			
Literature	Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005			

Course L0012: Win	d Energy Use - Focus Offshore
Тур	Lecture
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Skiba
Language	DE
Cycle	SoSe
Content	<ul> <li>Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering</li> <li>Physical fundamentals for utilization of wind energy</li> <li>Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships</li> <li>Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures</li> <li>Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection</li> <li>Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics</li> <li>Development and planning of offshore wind farms</li> <li>Operation and optimization of offshore wind farms</li> <li>Day excursion</li> </ul>
Literature	<ul> <li>Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage</li> <li>Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidelberg, 1997, 3. Auflage</li> <li>Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage</li> <li>Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage</li> <li>Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage</li> </ul>

Module M1163	L: Turbomachinery			
Courses				
<b>Title</b> Turbomachines (L1562 Turbomachines (L1563		<b>Typ</b> Lecture Recitation (large)	Hrs/wk 3 Section 1	<b>CP</b> 4 2
Module Responsible	Prof. Markus Schatz	(* 3*)		
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid D	ynamics, Heat	Transfer	
Educational Objectives	After taking part successfully, students	have reached	the following learn	ing results
Professional Competence	The students can			
Knowledge	distinguish the physical phenom	matic modelling		у,
Skills	The students are able to - understand the physics of Turbomach - solve excersises self-consistent.	ninery,		
Personal Competence				
Social Competence	The students are able to  • discuss in small groups and deve	elop an approac	ch.	
Autonomy	<ul> <li>The students are able to</li> <li>develop a complex problem self</li> <li>analyse the results in a critical w</li> <li>have an qualified exchange with</li> </ul>	vay,	;.	
	Independent Study Time 124, Study Ti	me in Lecture 5	6	
Credit points Course achievement				
	 Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Energy Systems: Specialisation Marine Product Development, Materials Development: Elective Compulsory Product Development, Materials and P Compulsory Product Development, Materials and Compulsory Theoretical Mechanical Engineering:	Engineering: E and Product roduction: Spec Production: Spe	lective Compulsory ion: Specialisation cialisation Product ecialisation Materi	on Production: Elective als: Elective

Compulsory

Course L1562: Turbomachines				
Тур	Lecture			
Hrs/wk	3			
СР	4			
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42			
Lecturer	Prof. Markus Schatz			
Language	DE			
Cycle	SoSe			
Content	<ul> <li>Application cases of turbomachinery</li> <li>Fundamentals of thermodynamics and fluid mechanics</li> <li>Design fundamentals of turbomachinery</li> <li>Introduction to the theory of turbine stage</li> <li>Design and operation of the turbocompressor</li> <li>Design and operation of the steam turbine</li> <li>Design and operation of the gas turbine</li> <li>Physical limits of the turbomachines</li> </ul>			
Literature	<ul> <li>Traupel: Thermische Turbomaschinen, Springer. Berlin, Heidelberg, New York</li> <li>Bräunling: Flugzeuggasturbinen, Springer., Berlin, Heidelberg, New York</li> <li>Seume: Stationäre Gasturbinen, Springer., Berlin, Heidelberg, New York</li> <li>Menny: Strömungsmaschinen, Teubner., Stuttgart</li> </ul>			

Course L1563: Turbomachines			
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Markus Schatz		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M1165	5: Ship Safety			
Courses				
Title		Тур	Hrs/wk	СР
Ship Safety (L1267)		Lecture	2	4
Ship Safety (L1268)		Recitation (large)	Section 2	2
Module Responsible	Prof. Stefan Krüger			
Admission Requirements	None			
Recommended Previous Knowledge	Ship Design, Hydrostatics, Statistical Pro	ocesses		
Educational Objectives		nave reached	the following learn	ing results
Professional				
Competence		v acposts ist	o the chin decise =	rocoss Thi-
Knowledge	The student shall lean to integrate safet includes the undertsnding and application of existing rules as well as t level which is targeted by a rule. Further, methods of demonstrating equi	he understan	ding of the sfatey	concept and
	he lectures starts with an overview all systems. The maritime safety organizations are introduced, their redifference between prescriptive and performance based rules is tackled. For influence of the rules on the deign is illustrated. Further, limitations of safety background are shown. Concepts of demonstrating equivalent levels of safety following fields will be treated.	esponses an oer different aftey rules v	d duties. Then, examples in ship with respect to t	the gerenal design, the he physical
Skills	- Freeboard, water- and weathertight sul	bdivisions, op	enings	
	- all aspects of intact stability, including	special proble	ems such as grain o	code
	- damage stability for passenger vessels	including Sto	ckholm agreement	<u>:</u>
	- damage stbility fopr cargo vessels			
	- on board stability, inclining experiment	and stability	booklet	
	- Relevant manoevering information			
Personal Competence				
· ·	The student learns to take responsibilty	_	of his designn.	:
	Responsible certification of technical des	_		
	Independent Study Time 124, Study Tim	e in Lecture 5	56	
Credit points Course				
achievement	Writton oxom			
Examination Examination duration and scale				

	Naval Architecture and Ocean Engineering: Core qualification: Compulsory							
Assignment for	Theoretical Mechanical Engineering: Technical Complementary Course: Elective							
the Following	Compulsory							
Curricula	Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective							
	Compulsory							

difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated . Further, limitations of saftey rules with respect to the physica background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  - Freeboard, water- and weathertight subdivisions, openings - all aspects of intact stability, including special problems such as grain code - damage stability for passenger vessels including Stockholm agreement - damage stbility fopr cargo vessels - on board stability, inclining experiment and stability booklet	Course L1267: Ship	Safety
Workload in Hours   Independent Study Time 92, Study Time in Lecture 28	Тур	Lecture
Independent Study Time 92, Study Time in Lecture 28   Prof. Stefan Krüger	Hrs/wk	2
Language DE  Cycle WiSe  The lectures starts with an overview about general safety concepts for technical systems. The maritime safety organizations are introduced, their responses and duties. Then, the gerenal difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  Content  Content  Content  Content  - Gamage stability for passenger vessels including Stockholm agreement  - damage stability for cargo vessels  - on board stability, inclining experiment and stability booklet	СР	4
Language  Cycle  WiSe  The lectures starts with an overview about general safety concepts for technical systems. The maritime safety organizations are introduced, their responses and duties. Then, the gerenal difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  Content  - Freeboard, water- and weathertight subdivisions, openings  - all aspects of intact stability, including special problems such as grain code  - damage stability for passenger vessels including Stockholm agreement  - damage stability fopr cargo vessels  - on board stability, inclining experiment and stability booklet	<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
The lectures starts with an overview about general safety concepts for technical systems. The maritime safety organizations are introduced, their responses and duties. Then, the gerenal difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  Conten	Lecturer	Prof. Stefan Krüger
The lectures starts with an overview about general safety concepts for technical systems. The maritime safety organizations are introduced, their responses and duties. Then, the gerenal difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  Content  - Freeboard, water- and weathertight subdivisions, openings - all aspects of intact stability, including special problems such as grain code - damage stability for passenger vessels including Stockholm agreement - damage stability for cargo vessels - on board stability, inclining experiment and stability booklet	Language	DE
systems. The maritime safety organizations are introduced, their responses and duties. Then, the gerena difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated. Further, limitations of saftey rules with respect to the physica background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  Content  - Freeboard, water- and weathertight subdivisions, openings - all aspects of intact stability, including special problems such as grain code - damage stability for passenger vessels including Stockholm agreement - damage stability fopr cargo vessels - on board stability, inclining experiment and stability booklet	Cycle	WiSe
Literature SOLAS, LOAD LINES, CODE ON INTACT STABILITY. Alle IMO, London.	Content	systems. The maritime safety organizations are introduced, their responses and duties. Then, the gerenal difference between prescriptive and performance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is illustrated . Further, limitations of saftey rules with respect to the physical background are shown. Concepts of demonstrating equivalent levels of safety by direct calculations are discussed. The following fields will be treated.  - Freeboard, water- and weathertight subdivisions, openings  - all aspects of intact stability, including special problems such as grain code  - damage stability for passenger vessels including Stockholm agreement  - damage stability foor cargo vessels  - on board stability, inclining experiment and stability booklet  - Relevant manoevering information

Course L1268: Ship	Course L1268: Ship Safety			
Тур	Recitation Section (large)			
Hrs/wk	2			
СР	2			
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Stefan Krüger			
Language	DE			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

M o d u l e M11 Hydrodynamid		Mano	euvral	bility	and	Shallow	Wate	r Ship
Courses								
<b>Title</b> Manoeuvrability of Shi Shallow Water Ship Hy	-		8)		<b>Typ</b> Lectu Lectu		Hrs/wk 2 2	<b>CP</b> 3 3
		oustafa Al	odel-Maks	oud				
Admission Requirements	None							
Recommended Previous Knowledge	B.Sc. Sc	chiffbau						
Educational Objectives		king part	successfu	ılly, stude	nts have r	eached the follo	owing learn	ing results
Professional Competence		donts lor	n the met	tion oqua	tion and h	now to doscribe	hydrodyn	amic forces
Knowledge	The students lern the motion equation and how to describe hydrodynamic forces. They'll will be able to develop methods for analysis of manoeuvring behaviour of ships and explaining the Nomoto equation. The students will know the common model tests as well as their assets and drawbacks.  Furthermore, the students lern the basics of assessment and prognosis of ship manoeuvrabilit. Basics of characteristics of flows around ships in shallow water regarding ship propulsion and manoeuvrability will be aquired.							
<i>Skills</i> <b>Personal</b>								
Competence Social Competence Autonomy	<u> </u>							
<b>Workload in Hours</b>	Indeper	ndent Stu	dy Time 1	24, Study	Time in Le	ecture 56		
Credit points								
Course achievement	None							
Examination		exam						
Examination duration and scale	180 mir	1						
Assignment for the Following Curricula	Ship an Theoret Compul	d Offshor ical Mec sory ical Mecl	e Technolo hanical Ei	ogy: Core ngineerin	qualificati g: Technic	re qualification on: Elective Co cal Complemer sation Maritim	mpulsory ntary Cour	se: Elective

Course L1597: Man	oeuvrability of Ships
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	WiSe
Content	<ul> <li>coordinates &amp; degrees of freedom</li> <li>governing equations of motion</li> <li>hydrodynamic forces &amp; moments</li> <li>ruder forces</li> <li>navigation based on linearised eq.of motion(exemplary solutions, yaw stability)</li> <li>manoeuvering test (constraint &amp; unconstraint motion)</li> <li>slender body approximation</li> </ul> Learning Outcomes Introduction into basic concepts for the assessment and prognosis ship manoeuvrabilit. Ability to develop methods for analysis of manoeuvring behaviour of ships.
Literature	<ul> <li>Crane, C. L. H., Eda, A. L., Principles of Naval Architecture, Chapter 9, Controllability, SNAME, New York, 1989</li> <li>Brix, J., Manoeuvring Technical Manual, Seehafen Verlag GmbH, Hamburg 1993</li> <li>Söding, H., Manövrieren, Vorlesungsmanuskript, Institut für Fluiddynamik und Schiffstheorie, TUHH, Hamburg, 1995</li> </ul>

Course L1598: Sha	llow Water Ship Hydrodynamics
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud, Dr. Norbert Stuntz
Language	DE/EN
Cycle	WiSe
Content	<ul> <li>Special Aspects of Shallow Water Hydrodynamics, Vertical and Horizontal Constraints, Irregularities in Channel Bed</li> <li>Fundamental Equations of Shallow Water Hydrodynamics</li> <li>Approximation of Shallow Water Waves, Boussinesq's Approximation</li> <li>Ship Waves in Deep Water and under critical, non-critical and supercritical Velocities</li> <li>Solitary Wves, Critical Speed Range, Extinction of Waves</li> <li>Aspects of Ship motions in Canals with limited water depth</li> </ul>
Literature	<ul> <li>PNA (1988): Principle of Naval Architecture, Vol. II, ISBN 0-939773-01-5</li> <li>Schneekluth (1988): Hydromechanik zum Schiffsentwurf</li> <li>Jiang, T. (2001): Ship Waves in Shallow Water, Fortschritt-Berichte VDI, Series 12, No 466, ISBN 3-18-346612-0</li> </ul>

Module M1268	3: Linear and Nonlinea	r Wav	es		
Courses					
Title			Тур	Hrs/wk	СР
Linear and Nonlinear W	Vaves (L1737)		Project-/problem- based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	INODE				
Recommended Previous Knowledge	Good Knowledge in Mathematics, Mechanics and Dynamics.				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	and research new terms and concepts.				
Skills	Students are able to apply existing methods and procesures of Wave Mechanics and to develop novel methods and procedures.				
Personal Competence					
Social Competence	Students can reach working results	also in gr	oups.		
Autonomy	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement					
Examination	Written exam				
Examination duration and scale					
Assignment for the Following Curricula	Compulsory	ngineerin ring: Sp	g: Core qualification ecialisation Maritim	n: Elective C e Technolo	gy: Elective

Course L1737: Linear and Nonlinear Waves				
Тур	Project-/problem-based Learning			
Hrs/wk	4			
СР	6			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
Lecturer	Prof. Norbert Hoffmann, Dr. Antonio Papangelo			
Language	DE/EN			
Cycle	WiSe			
Content	Introduction into the Dynamics of Linear and Nonlinear Waves.			
	G.B. Witham, Linear and Nonlinear Waves. Wiley 1999.			
Literature	C.C. Mei, Theory and Applications of Ocean Surface Waves. World Scientific 2004.			

Module M0548: Bioelectromagnetics: Principles and Applications				
Courses				
<b>Title</b> Bioelectromagnetics: Principles and Applications (L0371) Bioelectromagnetics: Principles and Applications (L0373)		<b>Typ</b> Lecture Recitation (small)	Hrs/wk 3 Section 2	<b>CP</b> 5
Module Responsible	Prof. Christian Schuster	(Sman)		
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, studer	nts have reached t	he following learn	ing results
Professional Competence				
Knowledge	Students can explain the basic bioelectromagnetics, i.e. the quantif in biological tissue. They can defin phenomena and order them correstields. They can give an overview of characterization of electromagnetic examples for therapeutic and diagmedical technology.	ication and applicate and exemplify sponding to wave ver measurement fields in practical	ation of electroma the most import length and frequ and numerical te applications . Th	gnetic fields ant physical ency of the chniques for ey can give
Skills	Students know how to apply varied electromagnetic fields in biological to make use of the elementary solution assess the most important effects to they can order the effects correspectively, and they can analyzed evelop validation strategies for the effects of electromagnetic fields from the make an appropriate choice.	issue. In order to ons of Maxwell's that these models responding to them in a quantielr predictions. The	do this they can r Equations. They predict for biolo wavelength and tative way. They ney are able to e	elate to and are able to gical tissue, frequency, are able to evaluate the
Personal Competence Social Competence				
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English.			
Workload in Hours	Independent Study Time 110, Study	Time in Lecture 70	0	

Credit points	6			
Course achievement	CompulsorBonus Yes 10 %	<b>Form</b> Presentation	Description	
Examination	Oral exam			
Examination duration and scale	45 min			
the Following	Electromagnetic Compa Electrical Engineering: International Managem Elective Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Compulsory Theoretical Mechanical Elective Compulsory	atibility: Elective Co Specialisation Medi ent and Engineering: Specialisation Art g: Specialisation Medi g: Specialisation Medicalisation Me	Microwave Engineering, ompulsory cal Technology: Elective Corag: Specialisation II. Electrical cificial Organs and Regeneral anagement and Business And Medical Technology and Colombian and Endoprosthe cialisation Bio- and Medical chnical Complementary Colombian and Colombian Complementary Colombian Colo	mpulsory al Engineering: tive Medicine: administration: antrol Theory: eses: Elective al Technology:

Course L0371: Bioe	electromagnetics: Principles and Applications
Тур	Lecture
Hrs/wk	3
СР	5
	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language	
Cycle	
	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)
	- Measurement techniques for characterization of electromagnetic fields
Content	- Behavior of electromagnetic fields of low frequency in biological tissue
333	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)
<del>-</del>	-

Course L0373: Bioelectromagnetics: Principles and Applications		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28	
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

l: Modelling and Optimiz	ation in Dyna	mics	
ems (L1632) ical systems (L1633)	<b>Typ</b> Lecture Lecture	Hrs/wk 2 2	<b>CP</b> 3 3
Prof. Robert Seifried			
None			
<ul> <li>Mathematics I, II, III</li> <li>Mechanics I, II, III, IV</li> <li>Simulation of dynamical Syst</li> </ul>	ems		
After taking part successfully, stude	nts have reached th	e following learn	ing results
Students demonstrate basic knowledge and understanding of modeling, simulation and analysis of complex rigid and flexible multibody systems and methods for optimizing dynamic systems after successful completion of the module.			
Students are able			
+ to think holistically			
+ to independently, securly and critically analyze and optimize basic problems the dynamics of rigid and flexible multibody systems  + to describe dynamics problems mathematically			problems of
+ to optimize dynamics problems			
Students are able to			
	us groups and to d	ocument the co	rresponding
Students are able to			
+ assess their knowledge by means	s of exercises.		
+ acquaint themselves with the n tasks.	ecessary knowledge	e to solve resear	ch oriented
Independent Study Time 124, Study	Time in Lecture 56		
6			
None			
Oral exam			
30 min			
	Prof. Robert Seifried  None  Mathematics I, II, III Mechanics I, II, IIII Mechanics I, II, IIII Mechanics I, III, IIII Mechanics I, III, IIII, IV Simulation of dynamical Systems after standard analysis of complex rigid and optimizing dynamic systems after standard standard systems after standard and flexible method by the dynamics of rigid and flexible method by the dynamics dynamics problems method by the dynamics dynamics problems method by the dynamics are able to the dynamics are able to the solve problems in heterogeneous results.  Students are able to the assess their knowledge by means the acquaint themselves with the netasks.  Independent Study Time 124, Study 6  None Oral exam	rems (L1632) Lecture Lecture  Prof. Robert Seifried  None  Mathematics I, II, III Mechanics II, III Mechanics II, II, III Mechanics II, III Mechanics II, III Mechanics II Mechanics III Mechanics II Mechani	rems (L1632) Lecture 2 Ical systems (L1633) Lecture 2 Prof. Robert Seifried  None  Mathematics I, II, IIII Mechanics I, III, IIII Mechanics III, IIII Mechanics IIII Mechanics IIII Mechanics IIII Mechanics IIIII Mechanics IIII Mechanics IIII Mechanics IIIII Mechanics IIII Mechanics IIIII Mechanics IIIII Mechanics IIII Mechanics IIII Mechanics IIII Mechanics IIIII Mechanics IIII Mechanics IIII Mechanics IIII Mechanics IIIII Mechanics IIIII Mechanics IIII Mechanics IIIII echanics IIIII Mechan

	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory			
Assignment for	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory			
the Following	Product Development, Materials and Production: Core qualification: Elective			
	Compulsory			
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective			
	Compulsory			

Course L1632: Flex	rible Multibody Systems
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried, Dr. Alexander Held
Language	DE
Cycle	WiSe
Content	<ol> <li>Basics of Multibody Systems</li> <li>Basics of Continuum Mechanics</li> <li>Linear finite element modelles and modell reduction</li> <li>Nonlinear finite element Modelles: absolute nodal coordinate formulation</li> <li>Kinematics of an elastic body</li> <li>Kinetics of an elastic body</li> <li>System assembly</li> </ol>
Literature	Schwertassek, R. und Wallrapp, O.: Dynamik flexibler Mehrkörpersysteme. Braunschweig, Vieweg, 1999.  Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.  Shabana, A.A.: Dynamics of Multibody Systems. Cambridge Univ. Press, Cambridge, 2004, 3. Auflage.

Course L1633: Opt	imization of dynamical systems
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	<ol> <li>Formulation and classification of optimization problems</li> <li>Scalar Optimization</li> <li>Sensitivity Analysis</li> <li>Unconstrained Parameter Optimization</li> <li>Constrained Parameter Optimization</li> <li>Stochastic optimization</li> <li>Multicriteria Optimization</li> <li>Topology Optimization</li> </ol>
Literature	Bestle, D.: Analyse und Optimierung von Mehrkörpersystemen. Springer, Berlin, 1994.  Nocedal, J., Wright, S.J.: Numerical Optimization. New York: Springer, 2006.

Module M1334	4: BIO II: Biomaterials			
Courses				
<b>Title</b> Biomaterials (L0593)	TypHrs/wkCPLecture23			
Module Responsible	I PIOL IVII DAPI IVIOTIO K			
Admission Requirements	LNONE			
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.			
Educational Objectives		:S		
Professional				
Competence Knowledge	The students can describe the materials of the human body and the materials being used in medical engineering, and their fields of use.			
Skills	The students can explain the advantages and disadvantages of different kinds biomaterials.	of		
Personal Competence				
Social Competence	The students are able to discuss issues related to materials being present or being used for replacements with student mates and the teachers.	ing		
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	INONE			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula		ne: / ry: on:		

Course L0593: Biomaterials	
Тур	Lecture
Hrs/wk	2
	·

<u>CP</u> Workload in Hours	3 Independent Study Time 62, Study Time in Lecture 28				
	Prof. Michael Morlock				
Language	EN				
Cycle					
	Topics to be covered include:				
	1. Introduction (Importance, nomenclature, relations)				
	2. Biological materials				
	2.1 Basics (components, testing methods)				
	2.2 Bone (composition, development, properties, influencing factors)				
	2.3 Cartilage (composition, development, structure, properties, influencing factors)				
	2.4 Fluids (blood, synovial fluid)				
	3 Biological structures				
	3.1 Menisci of the knee joint				
	3.2 Intervertebral discs				
	3.3 Teeth				
	3.4 Ligaments				
	3.5 Tendons				
Content	3.6 Skin				
	3.7 Nervs				
	3.8 Muscles				
	4. Replacement materials				
	4.1 Basics (history, requirements, norms)				
	4.2 Steel (alloys, properties, reaction of the body)				
	4.3 Titan (alloys, properties, reaction of the body)				
	4.4 Ceramics and glas (properties, reaction of the body)				
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)				
	4.6 Natural replacement materials				
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which are used for replacements in-vivo) Acquisition of basics for theses work in the area of biomechanics.				
	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.				
	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.				
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.				
Literature	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.				
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.				

Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlir Springer, 1996.

Module M1199	9: Advanced Funct	tional Mate	erials		
Courses					
<b>Title</b> Advanced Functional N	Naterials (L1625)		<b>Typ</b> Seminar	Hrs/wk 2	<b>CP</b> 6
Module Responsible	Prof. Patrick Huber				
Admission Requirements	None				
Recommended Previous Knowledge		als Science, e.g	g. Materials Sci	ence I/II	
Educational Objectives	LATTAR FAKINA NART CIICCACCTI	ully, students h	ave reached th	ne following learn	ing results
Professional Competence					
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particular metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.				
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications.				
Personal Competence					
Social Competence	The students are able to further.	o present solu <sup>i</sup>	tions to speci	alists and to de	velop ideas
	The students are able to				
Autonomy	<ul><li>assess their own str</li><li>gather new necessa</li></ul>				
Workload in Hours	Independent Study Time 1	Independent Study Time 152, Study Time in Lecture 28			
Credit points					
Course achievement	None				
Examination	<u></u>				
Examination duration and scale	30 min				
Assignment for the Following Curricula		and Manage Specialisation A Specialisation Specialisation Specialisation	ment: Specia rtificial Organs Implants and Medical Techr Management a	and Regeneration  d Endoprosthese  nology and Content  and Business Add	ve Medicine: es: Elective crol Theory: ministration:

Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L1625: Adv	anced Functional Materials
Тур	Seminar
Hrs/wk	2
СР	6
<b>Workload in Hours</b>	Independent Study Time 152, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber, Prof. Stefan Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ol> <li>Porous Solids - Preparation, Characterization and Functionalities</li> <li>Fluidics with nanoporous membranes</li> <li>Thermoplastic elastomers</li> <li>Optimization of polymer properties by nanoparticles</li> <li>Fiber composites in automotive</li> <li>Modeling of materials based on quantum mechanics</li> <li>Biomaterials</li> </ol>
Literature	Aktuelle Publikationen aus der Fachliteratur werden während der Veranstaltung bekanntgegeben.

Module M1342	2: Polymers				
Courses					
<b>Title</b> Structure and Propertice Processing and design	es of Polymers (L0389) with polymers (L1892)	<b>Typ</b> Lecture Lecture	Hrs/wk 2 2	<b>CP</b> 3 3	
Module Responsible	Dr. Hans Wittich				
Admission Requirements	None				
Recommended Previous Knowledge	Basics: chemistry / physics / mater	ial science			
Educational Objectives	After taking part successfully, stud	ents have reached the	e following learn	ing results	
Professional Competence					
Competence	Students can use the knowledge analysis.	of plastics and define	e the necessary	testing and	
Knowledge	They can explain the complex relat	ionships structure-pro	operty relationsh	nip and	
	the interactions of chemical str neighboring contexts (e.g. sustaina			to explain	
	Students are capable of				
Skills	- using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.				
	- selecting appropriate solutions for mechanical recycling problems and example stiffness, corrosion resistance.				
Personal Competence					
	Students can				
	- arrive at funded work results in h	eterogenius groups ar	nd document the	em.	
Social Competence	- provide appropriate feedback and handle feedback on their own performan constructively.				
	Students are able to				
	- assess their own strengths and weaknesses.				
Autonomy	- assess their own state of learning in specific terms and to define further work steps on this basis.				
	- assess possible consequences of their professional activity.				
	Independent Study Time 124, Stud	y Time in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	180 min				

scale	
the Following	Compulsory

Course L0389: Stru	cture and Properties of Polymers
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Hans Wittich
Language	DE
Cycle	WiSe
	- Structure and properties of polymers
	- Structure of macromolecules
	Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution
	- Morphology
	amorph, crystalline, blends
Content	- Properties
	Elasticity, plasticity, viscoelacity
	- Thermal properties
	- Electrical properties
	- Theoretical modelling
	- Applications
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

Course L1892: Processing and design with polymers			
Тур	Lecture		
Hrs/wk	2		
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Bodo Fiedler, Dr. Hans Wittich		
Language	DE/EN		
Cycle	WiSe		
Content	Manufacturing of Polymers: General Properties; Calendering; Extrusion; Injection Moulding; Thermoforming, Foaming; Joining Designing with Polymers: Materials Selection; Structural Design; Dimensioning		
Literature	Osswald, Menges: Materials Science of Polymers for Engineers, Hanser Verlag Crawford: Plastics engineering, Pergamon Press Michaeli: Einführung in die Kunststoffverarbeitung, Hanser Verlag Konstruieren mit Kunststoffen, Gunter Erhard, Hanser Verlag		

Module M1222	2: Design and Implemen	tation of Softwa	re Systeı	ns
Courses				
	cation of Software Systems (L1657) cation of Software Systems (L1658)	<b>Typ</b> Lecture Practical Course	<b>Hrs/wk</b> 2 2	<b>CP</b> 3 3
Admission Requirements	None			
	- Imperativ programming languages (C, Pascal, Fortran or similar) - Simple data types (integer, double, char, boolean), arrays, if-then-else, for, while, procedure and function calls			
Educational Objectives	After taking part successfully, stud	ents have reached the fo	llowing learn	ing results
Professional Competence				
Knowledge	Students are able to describe mech	natronic systems and def	ine requirem	ents.
Skills	Students are able to design and implement mechatronic systems. They are able to argue the combination of Hard- and Software and the interfaces.			
Personal Competence				
Social Competence	Students are able to work goal- broadening teamwork abilities and			earning and
Autonomy	Students are able to solve individually exercises related to this lecture with instructional direction. Students are able to plan, execute and summarize a mechatronic experiment.			
Workload in Hours	Independent Study Time 124, Stud	y Time in Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
the Following	Mechatronics: Core qualification: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory			

Course L1657: Des	Course L1657: Design and Implementation of Software Systems		
Тур	Lecture		
Hrs/wk			
СР	3		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Bernd-Christian Renner		
Language	EN		
Cycle	WiSe		
Content	nis course covers software design and implementation of mechatronic systems, rols for automation in Java. ontent:  Introduction to software techniques Procedural Programming Object oriented software design Java Event based programming Formal methods		
<ul> <li>"The Pragmatic Programmer: From Journeyman to Master"Andrew David Thomas, Ward Cunningham</li> <li>"Core LEGO MINDSTORMS Programming: Unleash the Power of the Platform" Brian Bagnall Prentice Hall PTR, 1st edition (March, 2002) 0130093645</li> <li>"Objects First with Java: A Practical Introduction using Bluej" David J. Ba &amp; Michael Kölling Prentice Hall/ Pearson Education; 2003, ISBN 0-13-0446</li> </ul>			

Course L1658: Design and Implementation of Software Systems	
Тур	Practical Course
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bernd-Christian Renner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1398	3: Selected Topics in Multibody Dynamics and Robotics		
Courses			
<b>Title</b> Formulas and Vehicles Driving (L1981)	Typ Hrs/wk CP - Mathematics and Mechanics in Autonomous Project-/problem- based Learning 2 6		
Module Responsible	Prof. Robert Seifried		
Admission Requirements	None		
	Mechanics IV, Applied Dynamics or Robotics		
Recommended Previous	Numerical Treatment of Ordinary Differential Equations		
Knowledge	Control Systems Theory and Design		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	After successful completion of the module students demonstrate deeper knowledge and understanding in selected application areas of multibody dynamics and robotics		
	Students are able		
	+ to think holistically		
Skills	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody systems		
	+ to describe dynamics problems mathematically		
	+ to implement dynamical problems on hardware		
Personal Competence			
	Students are able to		
Social Competence	+ solve problems in heterogeneous groups and to document the corresponding results and present them		
	Students are able to		
Autonomy	+ assess their knowledge by means of exercises and projects.		
Autonomy	+ acquaint themselves with the necessary knowledge to solve research oriented tasks.		
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28		
Credit points	6		
Course achievement	None		
Examination	Presentation		
Examination duration and scale	TBA		
the Following	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		

Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L1981: Formulas and Vehicles - Mathematics and Mechanics in Autonomous Driving			
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	6		
<b>Workload in Hours</b>	Vorkload in Hours Independent Study Time 152, Study Time in Lecture 28		
Lecturer	Prof. Robert Seifried		
Language	<b>Language</b> DE		
Cycle	Cycle WiSe		
Content			
	Seifried, R.: Dynamics of underactuated multibody systems, Springer, 2014		
Literature	Popp, K.; Schiehlen, W.: Ground vehicle dynamics, Springer, 2010		

Module M1249	9: Medical Imaging			
Courses				
<b>Title</b> Medical Imaging (L169 Medical Imaging (L169		<b>Typ</b> Lecture Recitation	Hrs/wk 2 Section 2	<b>CP</b> 3
		(small)	-	3
Module Responsible	Prof. Tobias Knopp			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, st	udents have reached t	he following learn	ing results
Professional Competence				
Knowledge Skills				
Personal Competence				
Social Competence Autonomy				
	Independent Study Time 124, St	udy Time in Lecture 56	5	
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Computer Science: Specialisation Computer Science: Specialisation Electrical Engineering: Specialisa Electrical Engineering: Specialisa Theoretical Mechanical Engineer Elective Compulsory Theoretical Mechanical Engineer Compulsory	n II: Intelligence Engine ation Medical Technolo ation Medical Technolo ering: Specialisation B	eering: Elective Co gy: Elective Comp gy: Elective Comp io- and Medical	ompulsory oulsory oulsory Technology:

Course L1694: Medical Imaging		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Tobias Knopp	
Language	DE	
Cycle	WiSe	
Content		
	Bildgebende Verfahren in der Medizin; O. Dössel; Springer, Berlin, 2000	
	<b>Bildgebende Systeme für die medizinische Diagnostik</b> ; H. Morneburg (Hrsg.); Publicis MCD, München, 1995	
Literature	<b>Introduction to the Mathematics of Medical Imaging</b> ; C. L.Epstein; Siam, Philadelphia, 2008	
	<b>Medical Image Processing, Reconstruction and Restoration</b> ; J. Jan; Taylor and Francis, Boca Raton, 2006	
	<b>Principles of Magnetic Resonance Imaging</b> ; ZP. Liang and P. C. Lauterbur; IEEE Press, New York, 1999	

Course L1695: Med	Course L1695: Medical Imaging	
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Tobias Knopp	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1336	6: Soft Computing - Introduction to Machine Learning			
Courses				
Title	Typ Hrs/wk CP			
	duction to Machine Learning (L1869) Lecture 4 6			
Module Responsible	Prof. Karl-Heinz Zimmermann			
Admission Requirements	INONA			
	Bachelor in Computer Science.  Basics in higher mathematics are inevitable, like calculus, linear algebra, greatheory, and optimization.	raph		
Educational Objectives	After taking part successfully, students have reached the following learning resu	ılts		
Professional Competence				
	Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models, phylogenetic tree models, classical regression and clustering methods, neural networks, and fuzzy controllers.			
Skills	Students can apply the relevant algorithms and determine their complexity, they can make use of the statistics language R.	and		
Personal				
Competence Social Competence	Students are able to solve specific problems alone or in a group and to present the results accordingly.			
Autonomy	Students are able to acquire new knowledge from newer literature and to associthe acquired knowledge to other fields.	Students are able to acquire new knowledge from newer literature and to associate the acquired knowledge to other fields.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	25 min			
Assignment for the Following Curricula				

Course L1869: Soft	Computing - Introduction to Machine Learning	
Тур	Lecture	
Hrs/wk	1	
СР	6	
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Karl-Heinz Zimmermann, Dr. Mehwish Saleemi	
Language	DE/EN	
Cycle	WiSe	
	Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models, phylogenetic tree models, neural networks, and fuzzy controllers. In particular, inference and learning in belief networks are important topics that the students should be able to master. Students can apply the relevant algorithms and determine their complexity, and they can make use of the statistics language R.	
Literature	<ol> <li>David Barber, Bayes Reasoning and Machine Learning, Cambridge Univ. Press, Cambridge, 2012.</li> <li>Volker Claus, Stochastische Automaten, Teubner, Stuttgart, 1971.</li> <li>Ernst Klement, Radko Mesiar, Endre Pap, Triangular Norms, Kluwer, Dordrecht, 2000.</li> <li>Timo Koski, John M. Noble, Bayesian Networks, Wiley, New York, 2009.</li> <li>Dimitris Margaritis, Learning Bayesian Network Model Structure from Data, PhD thesis, Carnegie Mellon</li> <li>University, Pittsburgh, 2003.</li> <li>Hidetoshi Nishimori, Statistical Physics of Spin Glasses and Information Processing, Oxford Univ. Press, London, 2001.</li> <li>James R. Norris, Markov Chains, Cambridge Univ. Press, Cambridge, 1996.</li> <li>Maria Rizzo, Statistical Computing with R, Chapman &amp; Hall/CRC, Boca Raton, 2008.</li> <li>Peter Sprites, Clark Glymour, Richard Scheines, Causation, Prediction, and Search, Springer, New York, 1993.</li> <li>Raul Royas, Neural Networks, Springer, Berlin, 1996.</li> <li>Lior Pachter, Bernd Sturmfels, Algebraic Statistics for Computational Biology, Cambridge Univ. Press, Cambridge, 2005.</li> <li>David A. Sprecher, From Algebra to Computational Algorithms, Docent Press, Boston, 2017.</li> <li>Karl-Heinz Zimmermann, Algebraic Statistics, TubDok, Hamburg, 2016.</li> </ol>	

Module M1294	1: Bioenergy				
Courses					
Courses Title		Тур		Hrs/wk	СР
Biofuels Process Techn Biofuels Process Techn		Lecture Recitation	Section	1	1
	modities from Agriculture and Forestry	(small)		_	
(L1769)		Lecture		1	1
Thermal Utilization of E Thermal Biomass Utiliz		Lecture Practical Course	9	2 1	2 1
Module Responsible	Prof. Martin Kaitschmitt				
Admission Requirements	None				
Recommended Previous Knowledge	none				
Educational Objectives	After taking part successfully, students	s have reached th	e follov	wing learr	ning results
Professional Competence					
Knowledge	Students are able to reproduce an in-depth outline of energy production from biomass, aerobic and anaerobic waste treatment processes, the gained products and the treatment of produced emissions.				
Skills	Students can apply the learned theoretical knowledge of biomass-based energy systems to explain relationships for different tasks, like dimesioning and design of biomass power plants. In this context, students are also able to solve computational tasks for combustion, gasification and biogas, biodiesel and bioethanol use.				
Personal Competence					
Social Competence	Students can participate in discussions to design and evaluate energy systems using biomass as an energy source.				
Autonomy	Students can independently exploit sources with respect to the emphasis of the lectures. They can choose and aquire the for the particular task useful knowledge. Furthermore, they can solve computational tasks of biomass-based energy systems independently with the assistance of the lecture. Regarding to this they can assess their specific learning level and can consequently define the further workflow.				
Workload in Hours	Independent Study Time 96, Study Tim	ne in Lecture 84			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	3 hours written exam				
	Bioprocess Engineering: Specialisation Compulsory Bioprocess Engineering: Specialisation Energy and Bioprocess Technology: Ele Energy and Environmental Engineerin Engineering: Elective Compulsory	n C - Bioeconomic ective Compulsory	Proce	ss Engine	ering, Focus

	Energy Systems: Specialisation Energy Systems: Elective Compulsory
the Following	International Management and Engineering: Specialisation II. Renewable Energy:
Curricula	Elective Compulsory
	Renewable Energies: Core qualification: Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Process Engineering: Specialisation Environmental Process Engineering: Elective
	Compulsory

Тур	Lecture
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Oliver Lüdtke
Language	DE
Cycle	WiSe
Content	<ul> <li>General introduction</li> <li>What are biofuels?</li> <li>Markets &amp; trends</li> <li>Legal framework</li> <li>Greenhouse gas savings</li> <li>Generations of biofuels <ul> <li>first-generation bioethanol</li> <li>raw materials</li> <li>fermentation distillation</li> <li>biobutanol / ETBE</li> <li>second-generation bioethanol</li> <li>bioethanol from straw</li> </ul> </li> <li>first-generation biodiesel <ul> <li>raw materials</li> <li>Production Process</li> <li>Biodiesel &amp; Natural Resources</li> </ul> </li> <li>HVO / HEFA</li> <li>second-generation biodiesel <ul> <li>Biodiesel from Algae</li> </ul> </li> <li>Biogas as fuel <ul> <li>the first biogas generation</li> <li>raw materials</li> <li>fermentation</li> <li>purification to biomethane</li> <li>Biogas second generation and gasification processes</li> </ul> </li> <li>Methanol / DME from wood and Tall oil ©</li> </ul>
Literature	<ul> <li>Skriptum zur Vorlesung</li> <li>Drapcho, Nhuan, Walker; Biofuels Engineering Process Technology</li> <li>Harwardt; Systematic design of separations for processing of biorenewables</li> <li>Kaltschmitt; Hartmann; Energie aus Biomasse: Grundlagen, Techniken und Verfahren</li> <li>Mousdale; Biofuels - Biotechnology, Chemistry and Sustainable Development</li> <li>VDI Wärmeatlas</li> </ul>

Course L0062: Biof	uels Process Technology
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Oliver Lüdtke
Language	DE
Cycle	WiSe
Content	<ul> <li>Life Cycle Assessment         <ul> <li>Good example for the evaluation of CO2 savings potential by alternative fuels - Choice of system boundaries and databases</li> </ul> </li> <li>Bioethanol production         <ul> <li>Application task in the basics of thermal separation processes (rectification, extraction) will be discussed. The focus is on a column design, including heat demand, number of stages, reflux ratio</li> </ul> </li> <li>Biodiesel production         <ul> <li>Procedural options for solid / liquid separation, including basic equations for estimating power, energy demand, selectivity and throughput</li> </ul> </li> <li>Biomethane production         <ul> <li>Chemical reactions that are relevant in the production of biofuels, including equilibria, activation energies, shift reactions</li> </ul> </li> </ul>
Literature	Skriptum zur Vorlesung

	Id Market for Commodities from Agriculture and Forestry  Lecture				
Hrs/wk					
CP					
	Independent Study Time 16, Study Time in Lecture 14				
	Prof. Michael Köhl, Bernhard Chilla				
Language					
Cycle	WiSe				
	1) Markets for Agricultural Commodities What are the major markets and how are markets functioning Recent trends in world production and consumption. World trade is growing fast. Logistics. Bottlenecks. The major countries with surplus production Growing net import requirements, primarily of China, India and many other countries. Tariff and non-tariff market barriers. Government interferences.  2) Closer Analysis of Individual Markets Thomas Mielke will analyze in more detail the global vegetable oil markets primarily palm oil, soya oil, rapeseed oil, sunflower oil. Also the raw material (the oilseed) as well as the byproduct (oilmeal) will be included. The major producers and consumers. Vegetable oils and oilmeals are extracted from the oilseed. The importance of vegetable oils and animal fats will be highlighted, primarily in the food industry in Europe and worldwide. But in the past 15 years there have also been rapidly rising global requirements of oils & fats for non-food purposes,				

primarily as a feedstock for biodiesel but also in the chemical industry.

Importance of oilmeals as an animal feed for the production of livestock and aquaculture

Oilseed area, yields per hectare as well as production of oilseeds. Analysis of the major oilseeds

worldwide. The focus will be on soybeans, rapeseed, sunflowerseed, groundnuts and cottonseed.

Content Regional differences in productivity. The winners and losers in global agricultural production.

3) Forecasts: Future Global Demand & Production of Vegetable Oils

Big challenges in the years ahead: Lack of arable land for the production of oilseeds, grains and other

crops. Competition with livestock. Lack of water. What are possible solutions? Need for better

education & management, more mechanization, better seed varieties and better inputs to raise yields.

The importance of prices and changes in relative prices to solve market imbalances (shortage

situations as well as surplus situations). How does it work? Time lags.

Rapidly rising population, primarily the number of people considered "middle class" in the years ahead.

Higher disposable income will trigger changing diets in favour of vegetable oils and livestock products.

Urbanization. Today, food consumption per caput is partly still very low in many developing countries,

primarily in Africa, some regions of Asia and in Central America. What changes are to be expected?

The myth and the realities of palm oil in the world of today and tomorrow.

Labour issues curb production growth: Some examples: 1) Shortage of labour in oil palm plantations in

Malaysia. 2) Structural reforms overdue for the agriculture in India, China and other countries to

become more productive and successful, thus improving the standard of living of smallholders.

**Literature** Lecture material

	rmal Utilization of Biomass
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe
	Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented.  The course is structured as follows:  • Biomass as an energy carrier within the energy system; use of biomass in
Content	<ul> <li>Germany and world-wide, overview on the content of the course</li> <li>Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste</li> <li>Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying</li> <li>Thermo-chemical conversion of solid biofuels         <ul> <li>Basics of thermo-chemical conversion</li> <li>Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use</li> <li>Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels</li> <li>Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a ray material</li> </ul> </li> <li>Physical-chemical conversion of biomass containing oils and/or fats: Basics oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine)</li> <li>Bio-chemical conversion of biomass         <ul> <li>Basics of bio-chemical conversion</li> <li>Biogas: Process technologies for plants using agricultural feedstock sewage sludge (sewage gas), organic waste fraction (landfill gas)</li> </ul> </li> </ul>
	technologies for the provision of bio methane, use of the digester slurry  Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage

Course L2386: The	rmal Biomass Utilization
Тур	Practical Course
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Martin Kaltschmitt, Dr. Isabel Höfer
Language	DE
Cycle	WiSe
Content	The experiments of the practical lab course illustrate the different aspects of heat generation from biogenic solid fuels. First, different biomasses (e.g. wood, straw or agricultural residues) will be investigated; the focus will be on the calorific value of the biomass. Furthermore, the used biomass will be pelletized, the pellet properties analysed and a combustion test carried out on a pellet combustion system. The gaseous and solid pollutant emissions, especially the particulate matter emissions, are measured and the composition of the particulate matter is investigated in a further experiment. Another focus of the practical course is the consideration of options for the reduction of particulate matter emissions from biomass combustion. In the practical course, a method for particulate matter reduction will be developed and tested. All experiments will be evaluated and the results presented.  Within the practical lab course the students discuss different technical-scientific tasks, both subject-specifically and interdisciplinary. They discuss various approaches to solving the problem and advise on the theoretical or practical implementation.
Literature	<ul> <li>Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science &amp; Business Media, 2016ISBN 978-3-662-47437-2</li> <li>Versuchsskript</li> </ul>

Module M1232	2: Arctic Technology			
Courses				
Title Ice Engineering (L1607	7)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 2
Ice Engineering (L1615	5)	Recitation Secti (small)	on 1	2
Ship structural design	for arctic conditions (L1575)	Project-/problem- based Learning	2	2
Module Responsible				
Admission Requirements	INONA			
Recommended Previous Knowledge	none			
Educational Objectives	After taking part successfully, students I	have reached the fol	lowing learn	ing results
Professional Competence				
Knowledge	The challenges and requirements due to ice can be explained. Ice loads can be explained and ice strengthening can be understood.			
Skills	The challenges and requirements due to ice can be assessed and the accuracy of these assessment can be evaluated. Calculation models to assess ice loads can be used and a structure can be designed accordingly.			
Personal Competence				
Social Competence	Students are capable to present their structural design and discuss their decisions constructively in a group.			eir decisions
Autonomy	Independent and individual assignment tasks can be carried out and presented whereby the capabilities to both, present and defend, the skills and findings will be achieved.			
Workload in Hours	Independent Study Time 110, Study Tim	ne in Lecture 70		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Naval Architecture and Ocean Engineeri Ship and Offshore Technology: Core qua Theoretical Mechanical Engineering: T	lification: Elective Co echnical Compleme	ompulsory ntary Cour	se: Elective

Course L1607: Ice E	Engineering Engineering				
Тур	Lecture				
Hrs/wk					
СР					
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28				
Lecturer	Dr. Walter Kuehnlein				
Language	DE/EN				
Cycle	WiSe				
	<ol> <li>Ice, Ice Properties, Ice Failure Modes and Challenges and Requirements due to Ice         <ul> <li>Introduction, what is/means ice engineering</li> <li>Description of different kinds of ice, main ice properties and different ice failure modes</li> <li>Why is ice so different compared to open water</li> <li>Presentation of design challenges and requirements for structures and systems in ice covered waters</li> </ul> </li> <li>Ice Load Determination and Ice Model Testing         <ul> <li>Overview of different empirical equations for simple determination of ice loads</li> <li>Discussion and interpretation of the different equations and results</li> <li>Introduction to ice model tests</li> <li>What are the requirements for ice model tests, what parameters have to be scaled</li> <li>What can be simulated and how to use the results of such ice model tests</li> </ul> </li> <li>Computational Modelling of Ice-Structure Interaction Processes         <ul> <li>Dynamic fracture and continuum mechanics for modelling ice-structure interaction processes</li> <li>Alternative numerical crack propagation modelling methods. Examples of cohesive element models for real life structures.</li> <li>Discussion of contribution of ice properties, hydrodynamics and rubble.</li> </ul> </li> <li>Ice Design Philosophies and Perspectives         <ul> <li>What has to be considered when designing structures or systems for ice covered waters</li> <li>What are the main differences compared to open water design</li> <li>Ice Management</li> <li>What are the main ice design philosophies and why is an integrated concept so important for ice</li> </ul> </li> <li>Learning Objectives</li> <li>The course will provide an introduction into ice engineering. Different kinds of ice and their</li></ol>				
Literature	<ul> <li>Proceedings OMAE</li> <li>Proceedings POAC</li> <li>Proceedings ATC</li> </ul>				

Course L1615: Ice Engineering		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Dr. Walter Kuehnlein	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1575: Ship structural design for arctic conditions			
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Sören Ehlers, Dr. Rüdiger Ulrich Franz von Bock und Polach		
Language	DE/EN		
Cycle	WiSe		
Content	The structural design under ice loads will be carried out for an individual case		
Literature	FSICR, IACS PC and assorted publications		

Module M1240	): Fatigue Stren	gth of Ships	and Offsl	ore :	Structu	ires
Courses						
<b>Title</b> Fatigue Strength of Sh	ips and Offshore Structure	es (L1521)	<b>Typ</b> Lecture		Hrs/wk 2	<b>CP</b> 3
Fatigue Strength of Sh	ips and Offshore Structure	es (L1522)	Recitation (small)	Section	2	3
Kesponsible	Prof. Sören Ehlers					
Admission Requirements	None					
	Structural analysis of s in mechanics and mechanics			and fur	ndamental	knowledge
Educational Objectives	After taking part succe	ssfully, students h	ave reached th	ne follov	wing learni	ng results
Professional Competence						
Competence	Students are able to					
Knowledge	<ul> <li>describe fatigue loads and stresses, as well as</li> <li>describe structural behaviour under cyclic loads.</li> </ul>					
Skills	Students are able to calculate life prediction based on the S-N approach as well as life prediction based on the crack propagation.					
Personal Competence						
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.					
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.					
	Independent Study Tim	ne 124, Study Time	e in Lecture 56			
Credit points	6					
Course achievement	None					
Examination	Oral exam					
Examination duration and scale	30 min					
Assignment for the Following Curricula	Naval Architecture and Ship and Offshore Tech Theoretical Mechanica Compulsory Theoretical Mechanica Compulsory	nology: Core quali Il Engineering: Te	fication: Electi chnical Comp	ve Com lement	npulsory ary Cours	e: Elective

gue Strength of Ships and Offshore Structures
Lecture
2
3
Independent Study Time 62, Study Time in Lecture 28
Prof. Wolfgang Fricke
EN
WiSe
1.) Introduction 2.) Fatigue loads and stresses 3.) Structural behaviour under cyclic loads - Structural behaviour under constant amplitude loading - Influence factors on fatigue strength - Material behaviour under contant amplitude loading - Special aspects of welded joints - Structural behaviour under variable amplitude loading 4.) Life prediction based on the S-N approach - Damage accumulation hypotheses - nominal stress approach - structural stress approach - notch stress approach - notch strain approach - numerical analyses 5.) Life prediction based on the crack propagation - basic relationships in fracture mechanics - description of crack propagation - numerical analysis - safety against unstable fracture
Siehe Vorlesungsskript

Course L1522: Fatigue Strength of Ships and Offshore Structures		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Wolfgang Fricke	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1235: Electrica	Power Systems	I: Introduction t	to Electrical
Power Systems			

Cours =				
Courses		_		
_	ms I: Introduction to Electrical Power Systems	<b>Typ</b> Lecture	Hrs/wk 3	<b>CP</b> 4
_	ms I: Introduction to Electrical Power Systems	Recitation 5	Section 2	2
(L1671)		(large)		
Module Responsible	Prof. Christian Becker			
Admission Requirements	INODE			
Recommended Previous Knowledge	Fundamentals of Electrical Engineering			
Educational Objectives	After taking part successfully, students ha	ave reached the	e following learn	ing results
Professional Competence				
	Students are able to give an overview of systems. They can explain in detail and power generation, transmission, storage equipment into electric power systems.	critically evalu	uate technologie	s of electric
Skills	With completion of this module the stude applications of the design, integration, do to assess the results.			
Personal Competence				
Social Competence	The students can participate in spec advance ideas and represent their own w			discussions,
Autonomy	Students can independently tap knowledg	ge of the emph	asis of the lectu	es.
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70		
Credit points	6			
Course achievement	LNODE			
Examination	Written exam			
Examination duration and scale	90 - 150 minutes			
Assignment for the Following Curricula	Computational Science and Engineer	ry Compulsory Elective Comp Specialisation E stems: Elective gram, 7 semes ring: Specialis ng: Specialisat	ulsory Energy Engineer e Compulsory ter): Specialisati sation II. Math	ing: Elective on Electrical nematics &

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L1670: Electrical Power Systems I: Introduction to Electrical Power Systems		
Тур	Lecture	
Hrs/wk	3	
СР	4	
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Christian Becker	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>fundamentals and current development trends in electric power engineering</li> <li>tasks and history of electric power systems</li> <li>symmetric three-phase systems</li> <li>fundamentals and modelling of eletric power systems         <ul> <li>lines</li> <li>transformers</li> <li>synchronous machines</li> <li>induction machines</li> <li>loads and compensation</li> <li>grid structures and substations</li> </ul> </li> <li>fundamentals of energy conversion         <ul> <li>electro-mechanical energy conversion</li> <li>thermodynamics</li> <li>power station technology</li> <li>renewable energy conversion systems</li> </ul> </li> <li>steady-state network calculation         <ul> <li>network modelling</li> <li>load flow calculation</li> <li>(n-1)-criterion</li> </ul> </li> <li>symmetric failure calculations, short-circuit power</li> <li>control in networks and power stations</li> <li>grid protection</li> <li>grid planning</li> <li>power economy fundamentals</li> </ul>	
Literature	<ul> <li>K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013</li> <li>A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017</li> <li>R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008</li> </ul>	

Course L1671: Elec	trical Power Systems I: Introduction to Electrical Power Systems
Тур	Recitation Section (large)
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	<ul> <li>fundamentals and current development trends in electric power engineering</li> <li>tasks and history of electric power systems</li> <li>symmetric three-phase systems</li> <li>fundamentals and modelling of eletric power systems         <ul> <li>lines</li> <li>transformers</li> <li>synchronous machines</li> <li>induction machines</li> <li>loads and compensation</li> <li>grid structures and substations</li> </ul> </li> <li>fundamentals of energy conversion         <ul> <li>electro-mechanical energy conversion</li> <li>thermodynamics</li> <li>power station technology</li> <li>renewable energy conversion systems</li> </ul> </li> <li>steady-state network calculation         <ul> <li>network modelling</li> <li>load flow calculation</li> <li>(n-1)-criterion</li> </ul> </li> <li>symmetric failure calculations, short-circuit power</li> <li>control in networks and power stations</li> <li>grid protection</li> <li>grid planning</li> <li>power economy fundamentals</li> </ul>
Literature	<ul> <li>K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013</li> <li>A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017</li> <li>R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008</li> </ul>

Courses					
<b>Title</b> Avionics of Safty Critics	al Systems (I 1640	)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Avionics of Safty Critics	-		Recitation	Section <sub>1</sub>	1
Avionics of Safty Critics	-		(small) Practical Course	e 1	2
Module Responsible		,			_
Admission Requirements	None				
Recommended Previous Knowledge	Mathema     Electrical     Information	tics Engineering			
Educational Objectives	After taking part	t successfully, studer	ts have reached th	e following lear	ning results
Professional Competence					
Knowledge	<ul><li>avionics</li><li>denote pr</li><li>depict the</li><li>can comp</li></ul>	the most important rocesses and standar e principles of Integra pare hardware and bu e difficulties of devel	ds of safety-critical ated Modular Avion as systems used in	software develocs (IMA) avionics	opment
Skills	<ul><li>program /</li><li>plan avio</li></ul>	eal-time hardware ar A653 applications nics architectures up st scripts and assess	to a certain extend	I	
Personal Competence					
Social Competence	<ul> <li>exchange</li> </ul>	velop solutions in inhe information formally evelopment results i	with other teams		
Autonomy		nd the requirements ously derive concepts			cal avionics

Credit points	6		
Course achievement	Compulsor <b>B</b> onus Yes None	Form Subject theoretical practical work	<b>Description</b> and
Examination	Oral exam		
Examination duration and scale	30 min		
the Following	Elective Compulsory Aircraft Systems Engine Aircraft Systems Engine Aircraft Systems Engine Theoretical Mechanica Compulsory	eering: Specialisation Airo eering: Specialisation Cab eering: Specialisation Avi Engineering: Technica	and Power Systems Engineering: craft Systems: Elective Compulsory bin Systems: Elective Compulsory onic Systems: Compulsory I Complementary Course: Elective ation Aircraft Systems Engineering:

Course L1640: Avid	onics of Safty Critical Systems
Тур	Lecture
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Martin Halle
Language	DE
Cycle	WiSe
Content	Avionics are all kinds off flight electronics. Today there is no aircraft system function without avionics, and avionics are one main source of innovation in aerospace industry. Since many system functions are highly safety critical, the development of avionics hardware and software underlies mandatory constraints, technics, and processes. It is inevitable for system developers and computer engineers in aerospace industry to understand and master these. This lecture teaches the risks and techniques of developing safety critical hardware and software; major avionics components; integration; and test with a practical orientation. A focus is on Integrated Modular Avionics (IMA). The lecture is accompanied by a mandatory and laboratory exercises.  Content:  1. Introduction and Fundamentals 2. History and Flight Control 3. Concepts and Redundancy 4. Digital Computers 5. Interfaces and Signals 6. Busses 7. Networks
	7. Networks 8. Aircraft Cockpit 9. Software Development 10. Model-based Development 11. Integrated Modular Avionics I 12. Integrated Modular Avionics II
Literature	<ul> <li>Moir, I.; Seabridge, A. &amp; Jukes, M., Civil Avionics Systems Civil Avionics Systems, John Wiley &amp; Sons, Ltd, 2013</li> <li>Spitzer, C. R. Spitzer, Digital Avionics Handbook, CRC Press, 2007</li> <li>FAA, Advanced Avionics Handbook U.S. Department of Transportation Federa Aviation Administration, 2009</li> <li>Moir, I. &amp; Seabridge, A. Aircraft Systems, Wiley, 2008, 3</li> </ul>

Course L1641: Avid	Course L1641: Avionics of Safty Critical Systems		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	1		
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Dr. Martin Halle		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1652: Avid	Course L1652: Avionics of Safty Critical Systems		
Тур	Practical Course		
Hrs/wk	1		
СР	2		
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Dr. Martin Halle		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

## **Supplement Modules Core Studies**

Allows to obtain missing basics form bachelor studies. For further information, see FSPO.

Module M0960:	Mechanics	IV	(Oscillations,	Analytical	Mechanics,
Multibody System	ns, Numerica	al M	lechanics)		

	items, Numerical Mechan	,		
Courses				
Title		Тур	Hrs/wk	СР
Mechanics IV (Oscillati Mechanics) (L1137)	ons, Analytical Mechanics, Numerical	Lecture	3	3
Mechanics IV (Oscillati Mechanics) (L1138)	ons, Analytical Mechanics, Numerical	Recitation (small)	Section 2	2
Mechanics IV (Oscillati Mechanics) (L1139)	ons, Analytical Mechanics, Numerical	Recitation (large)	Section 1	1
Module Responsible	Prof. Robert Seifried			
Admission Requirements	INODE			
Recommended Previous Knowledge	Mathematics I-III and Mechanics I-III			
Educational Objectives	After taking part successfully studer	nts have reached	the following learn	ing results
Professional Competence				
Knowledge	<ul> <li>the students can</li> <li>describe the axiomatic procedure used in mechanical contexts;</li> <li>explain important steps in model design;</li> <li>present technical knowledge.</li> </ul>			
Skills	explain the important elemer model formation, and apply it     apply basic methods to engine     estimate the reach and boun applicable to wider problem se	to the context of eering problems; daries of the me	their own problem	s;
Personal Competence				
Social Competence	The students can work in groups and	support each ot	her to overcome di	fficulties.
Autonomy	Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those.			
<b>Workload in Hours</b>	Independent Study Time 96, Study T	ime in Lecture 84	1	
Credit points	6			
Course achievement	LNONE			
Examination	Written exam			
Examination duration and scale	120 min			

	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Naval
	Architecture: Compulsory
	Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory
Assignment for	General Engineering Science (English program, 7 semester): Specialisation
the Following	Mechanical Engineering: Compulsory
Curricula	General Engineering Science (English program, 7 semester): Specialisation Naval
	Architecture: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
	Biomedical Engineering: Compulsory
	Mechanical Engineering: Core qualification: Compulsory
	Mechatronics: Core qualification: Compulsory
	Naval Architecture: Core qualification: Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course Core Studies:
	Elective Compulsory

Course L1137: Med	hanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics)
Тур	Lecture
Hrs/wk	3
СР	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	SoSe
Content	<ul> <li>Elements of vibration theory</li> <li>Vibration of Multi-degree of freedom systems</li> <li>Analytical Mechanics</li> <li>Multibody Systems</li> <li>Numerical methods for time integration</li> <li>Introduction to Matlab</li> </ul>
Literature	<ul> <li>K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).</li> <li>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1-4. 11. Auflage, Springer (2011).</li> <li>W. Schiehlen, P. Eberhard: Technische Dynamik, Springer (2012).</li> </ul>

Course L1138: Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics)	
Тур	Recitation Section (small)
Hrs/wk	2
СР	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1139: Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics)		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Robert Seifried	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses				
Title	2 (Partial Differential Equations) (L1043)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 1
·	2 (Partial Differential Equations) (L1044)	Recitation (small)	Section 1	1
Differential Equations	2 (Partial Differential Equations) (L1045)	Recitation (large)	Section 1	1
Complex Functions (L1	.038)	Lecture	2	1
Complex Functions (L1	041)	Recitation (small)	Section 1	1
Complex Functions (L1	042)	Recitation (large)	Section 1	1
Module Responsible	Prof. Anusch Taraz			
Admission Requirements	None			
Recommended				
Previous Knowledge	Mathematics 1 - III			
Educational Objectives	After taking part successfully, students	s have reached	the following learn	ning results
Professional Competence				
Knowledge	They know proof strategies and	examples. Innections betw nections with t can reproduce	een these concept he help of example them.	es. They are
Skills	<ul> <li>Students can model problems in studied in this course. Moreo applying established methods.</li> <li>Students are able to discover a the concepts studied in the cour</li> <li>For a given problem, the student approach, and are able to critical</li> </ul>	ver, they are nd verify furtherse. dents can dev	capable of solvirer logical connections  velop and execute	ng them b
Personal Competence				
Social Competence	<ul> <li>Students are able to work to mathematics as a common lang</li> <li>In doing so, they can communic their cooperating partners. Mo and deepen the understanding of</li> </ul>	uage. cate new conce reover, they c	epts according to t	the needs o
Autonomy	<ul> <li>Students are capable of checking on their own. They can specify get help in solving them.</li> <li>Students have developed sufficients.</li> </ul>	open question	s precisely and kno	ow where t

	periods in a goal-oriented manner on hard problems.
	Independent Study Time 68, Study Time in Lecture 112
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (Complex Functions) + 60 min (Differential Equations 2)
the Following	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory Computer Science: Specialisation Computational Mathematics: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Computer Science: Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core qualification: Compulsory Engineering Science: Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering: Specialisation Mechanical Engineering: Specialisation Naval Architecture: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory Mechanical Engineering: Specialisation: Compulsory Mechanical Engineering: Specialisation: Compulsory Mechanical Engineering: Engineering: Technical Complementary Course Core S

Course L1043: Differential Equations 2 (Partial Differential Equations)	
Тур	Lecture
Hrs/wk	2
СР	1
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	Main features of the theory and numerical treatment of partial differential equations  Examples of partial differential equations First order quasilinear differential equations Normal forms of second order differential equations Harmonic functions and maximum principle Maximum principle for the heat equation Wave equation Liouville's formula Special functions Difference methods Finite elements
Literature	http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html

Course L1044: Differential Equations 2 (Partial Differential Equations)		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dozenten des Fachbereiches Mathematik der UHH	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1045: Differential Equations 2 (Partial Differential Equations)		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dozenten des Fachbereiches Mathematik der UHH	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1038: Complex Functions		
Тур	Lecture	
Hrs/wk	2	
СР	1	
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28	
Lecturer	Dozenten des Fachbereiches Mathematik der UHH	
Language	DE	
Cycle	SoSe	
Content	<ul> <li>Main features of complex analysis</li> <li>Functions of one complex variable</li> <li>Complex differentiation</li> <li>Conformal mappings</li> <li>Complex integration</li> <li>Cauchy's integral theorem</li> <li>Cauchy's integral formula</li> <li>Taylor and Laurent series expansion</li> <li>Singularities and residuals</li> <li>Integral transformations: Fourier and Laplace transformation</li> </ul>	
Literature	http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html	

Course L1041: Complex Functions	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1042: Complex Functions	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Courses				
Title Introduction to Control	Systems (L0654)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 4
Introduction to Control		Recitation (small)	Section 2	2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	Representation of signals and systems in time and frequency domain, Laplace transform			
	After taking part successfully, studer	nts have reached	the following learr	ing results
Professional Competence				
Knowledge	<ul> <li>Students can represent dynamic system behavior in time and frequency domain, and can in particular explain properties of first and second order systems</li> <li>They can explain the dynamics of simple control loops and interpret dynamic properties in terms of frequency response and root locus</li> <li>They can explain the Nyquist stability criterion and the stability margins derived from it.</li> <li>They can explain the role of the phase margin in analysis and synthesis of control loops</li> <li>They can explain the way a PID controller affects a control loop in terms of its frequency response</li> <li>They can explain issues arising when controllers designed in continuous time domain are implemented digitally</li> </ul>			
Skills	<ul> <li>Students can transform more frequency domain and vice verence of the can simulate and assess.</li> <li>They can design PID controll tuning rules.</li> <li>They can analyze and synther locus and frequency response.</li> <li>They can calculate discrete-tocontinuous-time and use it fore the carrying out these tasks.</li> </ul>	rsa the behavior of s ers with the help size simple contr techniques ime approximatio digital implemen	ystems and controllers tation	ol loops gler-Nichols help of roo designed
Personal Competence Social Competence	Students can work in small groue experimentally validate their control	ler designs		
Autonomy	Students can obtain information fr documentation, experiment guides) They can assess their knowledge in learning progress.	and use it when s	olving given probl	ems.

	<u></u>	
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement	None	
Examination	Written exam	
Examination duration and scale	120 min	
the Following	General Engineering Science (German program, 7 semester): Core qualification: Compulsory Bioprocess Engineering: Core qualification: Compulsory Computer Science: Specialisation Computational Mathematics: Elective Compulsory Data Science: Core qualification: Elective Compulsory Electrical Engineering: Core qualification: Compulsory Energy and Environmental Engineering: Core qualification: Compulsory Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Engineering: Compulsory General Engineering: Compulsory General Engineering: Compulsory General Engineering: Compulsory General Engineering: Compulsory General Engineering: Compulsory General Engineering: Compulsory General Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering, Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering	

Course L0654: Intro	oduction to Control Systems
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	DE
Cycle	WiSe
Content	Signals and systems  Linear systems, differential equations and transfer functions First and second order systems, poles and zeros, impulse and step response Stability  Feedback systems  Principle of feedback, open-loop versus closed-loop control Reference tracking and disturbance rejection Types of feedback, PID control System type and steady-state error, error constants Internal model principle  Root locus techniques Root locus design of PID controllers  Frequency response techniques  Bode diagram Minimum and non-minimum phase systems Nyquist plot, Nyquist stability criterion, phase and gain margin Loop shaping, lead lag compensation Frequency response interpretation of PID control  Time delay systems  Root locus and frequency response of time delay systems Smith predictor  Digital control Sampled-data systems, difference equations Tustin approximation, digital implementation of PID controllers  Software tools Introduction to Matlab, Simulink, Control toolbox Computer-based exercises throughout the course
Literature	<ul> <li>Werner, H., Lecture Notes "Introduction to Control Systems"</li> <li>G.F. Franklin, J.D. Powell and A. Emami-Naeini "Feedback Control of Dynamic Systems", Addison Wesley, Reading, MA, 2009</li> <li>K. Ogata "Modern Control Engineering", Fourth Edition, Prentice Hall, Upper Saddle River, NJ, 2010</li> <li>R.C. Dorf and R.H. Bishop, "Modern Control Systems", Addison Wesley, Reading, MA 2010</li> </ul>

Course L0655: Introduction to Control Systems	
Тур	Recitation Section (small)
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Courses				
Title Numerical Mathematics I (L0417)		<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3
Numerical Mathematics	s I (L0418)	Recitation (small)	Section 2	3
Module Responsible	Prof. Sabine Le Borne			
Admission Requirements	None			
Recommended Previous Knowledge	<ul> <li>Mathematik I + II for Engin Linear Algebra I + II for Tec</li> <li>basic MATLAB knowledge</li> </ul>		rman or english) <b>o</b>	<b>r</b> Analysis 8
Educational Objectives	After taking part successfully, stu	dents have reached	the following learn	ing results
Professional Competence				
Knowledge	<ul> <li>name numerical method problems, eigenvalue pro explain their core ideas,</li> <li>repeat convergence statem</li> <li>explain aspects for the practo computational and stora</li> </ul>	blems, nonlinear ronents for the numerious of notices.	oot finding problecal methods,	ems and t
Skills	<ul> <li>Students are able to</li> <li>implement, apply and come</li> <li>justify the convergence be problem and solution algor</li> <li>select and execute a suitable</li> </ul>	haviour of numerica ithm,	I methods with re	spect to th
Personal Competence	Students are able to			
Social Competence	<ul><li>work together in heter</li></ul>	and background kn each other with pr	owledge), explain	theoretica
Autonomy	<ul> <li>to assess whether the su better solved individually o</li> <li>to assess their individual seek help.</li> </ul>	r in a team,	·	
Workload in Hours	Independent Study Time 124, Stu	dy Time in Lecture 5	6	
Credit points	6			
Course	None			
achievement				

duration and	90 minutes
scale	
	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation
	Biomedical Engineering: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation
	Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation
	Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory
	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory
	Computer Science: Specialisation Computational Mathematics: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective
	Compulsory
	Data Science: Core qualification: Compulsory
	Electrical Engineering: Core qualification: Elective Compulsory
	Engineering Science: Core qualification: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
Assignment for	Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory
the Following	Conoral Engineering Science (English program 7 competer). Core qualifications
Curricula	Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
	Computer Science: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
	Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
	Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory General Engineering Science (English program, 7 semester): Specialisation
	Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
	Biomedical Engineering: Compulsory
	Computational Science and Engineering: Core qualification: Compulsory
	Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective
	Compulsory
	Mechanical Engineering: Specialisation Theoretical Mechanical Engineering:
	Compulsory  Machanical Engineering: Specialisation Energy Systems: Elective Compulsory
	Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies:
	Elective Compulsory
	Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0417: Numerical Mathematics I		
Тур	Lecture	
Hrs/wk	2	
СР	3	
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Sabine Le Borne	
Language	EN	
Cycle	WiSe	
Content	<ol> <li>Error analysis: Number representation, error types, conditioning and stability</li> <li>Interpolation: polynomial and spline interpolation</li> <li>Numerical integration and differentiation: order, Newton-Cotes formula, error estimates, Gaussian quadrature, adaptive quadrature, difference formulas</li> <li>Linear systems: LU and Cholesky factorization, matrix norms, conditioning</li> <li>Linear least squares problems: normal equations, Gram.Schmidt and Householder orthogonalization, singular value decomposition, regularization</li> <li>Eigenvalue problems: power iteration, inverse iteration, QR algorithm</li> <li>Nonlinear systems of equations: Fixed point iteration, root-finding algorithms for real-valued functions, Newton and Quasi-Newton methods for systems</li> </ol>	
Literature	<ul> <li>Stoer/Bulirsch: Numerische Mathematik 1, Springer</li> <li>Dahmen, Reusken: Numerik für Ingenieure und Naturwissenschaftler, Springer</li> </ul>	

Course L0418: Numerical Mathematics I	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

## **Thesis**

## **Master Thesis**

Module M-002	2: Master Thesis
Courses	
Title	Typ Hrs/wk CP
Module Responsible	Professoren der TUHH
Admission Requirements	
Recommended Previous Knowledge	
Educational Objectives	I After taking part cuccectilly chidents have reached the following learning recults
Professional Competence	
Knowledge	<ul> <li>The students can use specialized knowledge (facts, theories, and methods) or their subject competently on specialized issues.</li> <li>The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject, describing current developments and taking up a critical position on them.</li> <li>The students can place a research task in their subject area in its context and describe and critically assess the state of research.</li> </ul>
Skills	<ul> <li>The students are able:</li> <li>To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question.</li> <li>To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or incompletely defined problems in a solution-oriented way.</li> <li>To develop new scientific findings in their subject area and subject them to a critical assessment.</li> </ul>
Personal Competence	
Social Competence	<ul> <li>Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way.</li> <li>Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees while upholding their owr assessments and viewpoints convincingly.</li> </ul>
	Students are able:  • To structure a project of their own in work packages and to work them off accordingly.

Autonomy	<ul> <li>To work their way in depth into a largely unknown subject and to access the information required for them to do so.</li> <li>To apply the techniques of scientific work comprehensively in research of their own.</li> </ul>
<b>Workload in Hours</b>	Independent Study Time 900, Study Time in Lecture 0
Credit points	
Course achievement	None
Examination	Thesis
Examination duration and scale	According to General Regulations
Assignment for the Following Curricula	Logistics, intrastructure and Mobility: Thesis: Compulsory