Module Manual

Master of Science (M.Sc.) Theoretical Mechanical Engineering

Cohort: Winter Term 2021 Updated: 31st May 2021

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Program description

Content

The 4-semester research-oriented master's degree (MSc) "Theoretical Mechanical Engineering" builds on research-oriented Mechanical Engineeringoriented 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

nportant	
Nodule M0523: Busin	ess & Management
Module Responsible	Dref Matthias Mayor
•	
Admission Requirements	
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	 Students are able to find their way around selected special areas of management within the scope of business managem Students are able to explain basic theories, categories, and models in selected special areas of business management. Students are able to interrelate technical and management knowledge.
Skills	 Students are able to apply basic methods in selected areas of business management. Students are able to explain and give reasons for decision proposals on practical issues in areas of business managemen
Personal Competence Social Competence	 Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems
Autonomy	• Students are capable of acquiring necessary knowledge independently by means of research and preparation of material
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.

Module Responsible	Dagmar Richter
Admission Requirements	
Recommended Previous	None
Knowledge	
-	After taking part successfully, students have reached the following learning results
Professional Competence Knowledae	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 fu Self-reliance, self-management, collaboration and professional and personnel management competences. The departme implements these training objectives in its teaching architecture , in its teaching and learning arrangements , in teach 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 nontechn complementary courses.
	The Learning Architecture
	consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechn academic programms follow the specific profiling of TUHH degree courses.
	The learning architecture demands and trains independent educational planning as regards the individual development 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 two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation 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 dea with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberat encouraged in specific courses.
	Fields of Teaching
	are based on research findings from the academic disciplines cultural studies, social studies, arts, historical stud communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the wir semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start- 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 georiented 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. Th differences are reflected in the practical examples used, in content topics that refer to different professional application conte 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 leaders 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 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 represental 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.
Skills	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 species 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

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Personal Competence	
-	ersonal Competences (Social Skills)
	 udents 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 gender-sensitive 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.
	 ersonal Competences (Self-reliance) udents are able in selected areas to reflect on their own profession and professionalism in the context of real-life fields of application to organize themselves and their own learning processes to reflect and decide questions in front of a broad education background to communicate a nontechnical item in a competent way in writen form or verbaly to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)
Workload in Hours De	epends on choice of courses
Credit points 6	

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

Courses				
Fitle		Тур	Hrs/wk	СР
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous	see FSPO			
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	see FSPO			
Autonomy	see FSPO			
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the	Theoretical Mechanical Engineering: Core qua	alification: Elective Compulsory		
Following Curricula				

Courses				
Гitle		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and	Mechanics II (Hydrostatics, Kinematics, Dyna	amics)	
Knowledge	Mathematics I, II, III (in particular differential equ	ations)		
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
-	The students possess an in-depth knowledge i	regarding the derivation of the finite eleme	ent method and	are able to give
Kilowieuge	overview of the theoretical and methodical basis		ine meenoù una	are able to give
Skills	The students are capable to handle engineering	problems by formulating suitable finite eler	ments, assemblir	ng the correspond
	system matrices, and solving the resulting system	m of equations.		
Personal Competence				
Social Competence	Students can work in small groups on specific pro	oblems to arrive at joint solutions.		
Autonomy	y The students are able to independently solve challenging computational problems and develop own finite element routin			
	Problems can be identified and the results are cr			
Westleed in Herry	ladan andart Chudu Tina 124. Chudu Tina in Lad			
	Independent Study Time 124, Study Time in Lect	ure 56		
Credit points Course achievement		Description		
Course achievement	No 20 % Midterm			
Examination	Written exam			
Examination duration and				
scale				
	Civil Engineering: Core qualification: Compulsory			
-	Energy Systems: Core qualification: Elective Com			
· · · · · · · · · · · · · · · · · · ·	Aircraft Systems Engineering: Specialisation Airc			
	Aircraft Systems Engineering: Specialisation Air			
	Aircraft Systems Engineering: Core qualification:			
	International Management and Engineering: Spe		ory	
	International Management and Engineering: Spe		-	ompulsory
	Mechatronics: Core qualification: Compulsory			
	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Managem		mpulsory	
	Biomedical Engineering: Specialisation Medical T			
	Biomedical Engineering: Specialisation Artificial (
	Product Development, Materials and Production:	Core qualification: Compulsory		
	Technomathematics: Specialisation III. Engineeri	ng Science: Elective Compulsory		

Course L0291: Finite Elemen	t Methods
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	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 Elemen	ourse L0804: Finite Element Methods		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	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		

Courses				
Title		Тур	Hrs/wk	СР
Control Systems Theory and Desig Control Systems Theory and Desig		Lecture Recitation Section (small)	2 2	4 2
Module Responsible		Rectation Section (Smail)	Z	2
Admission Requirements				
	Introduction to Control Systems			
Knowledge	incroduction to control systems			
-	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge Skills	 Students can explain how linear dynamic response to initial states or external excita They can explain the system properties c estimation, respectively They can explain the significance of a min They can explain observer-based state fee They can explain the z-transform and its r They can explain the z-transform and its r They can explain the experimental identifies be solved by solving a normal equation They can explain how a state space models Students can transform transfer function r They can design LQG controllers for multive They can identify transfer function models They can identify transfer function models They can astary out a controller design be for a given sampling rate They can carry out all these tasks using 	ontrollability and observability, and their relation edback and how it can be used to achieve tra- input multi-output systems elationship with the Laplace Transform transfer function models of discrete-time syst ication of ARX models of dynamic systems, an I can be constructed from a discrete-time imp models into state space models and vice vers rability and construct minimal realisations	ationship to state cking and disturt tems nd how the ident pulse response a ain, and decide	e feedback and s bance rejection ification problem which is appropr
	Simulink) Students can work in small groups on specific pro Students can obtain information from provided when solving given problems.		ation, experimer	nt guides) and us
	They can assess their knowledge in weekly on-lir	ne tests and thereby control their learning pro	ogress.	
Workload in Hours	Independent Study Time 124, Study Time in Lect	cure 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Electrical Engineering: Core qualification: Compu	llsory		
Following Curricula	Energy Systems: Core qualification: Elective Com			
	Aircraft Systems Engineering: Core qualification:		Les et	
	Computational Science and Engineering: Special International Management and Engineering: Spe			
	International Management and Engineering: Spe	• •		
	Mechanical Engineering and Management: Speci		si y	
	Mechatronics: Core qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial (Organs and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants	• •	,	
	Biomedical Engineering: Specialisation Medical T	echnology and Control Theory: Compulsory		
	Biomedical Engineering: Specialisation Managem	nent and Business Administration: Elective Co	mpulsory	
	Product Development, Materials and Production:			
	Theoretical Mechanical Engineering: Core qualified	cation: Compulsory		

Түр	Lecture
Hrs/wk	
CP	
_	Independent Study Time 92, Study Time in Lecture 28
	Prof. Herbert Werner
Language	
Cycle	
	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 Simulink
	Software tools
	Matlab/Simulink
Literature	
	Werner, H., Lecture Notes "Control Systems Theory and Design"
	T. Kailath "Linear Systems", Prentice Hall, 1980
	K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997
	 L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

Course L0657: Control Systems Theory and Design	
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	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Courses				
Title		Тур	Hrs/wk	СР
Flexible Multibody Systems (L1632) Optimization of dynamical systems		Lecture Lecture	2	3
Module Responsible		Lecture	2	5
Admission Requirements				
Recommended Previous	None			
Knowledge	Mathematics I, II, III			
	Mechanics I, II, III, IV			
	 Simulation of dynamical Systems 			
Educational Objectives	After taking part successfully, students I	nave reached the following learning results		
Professional Competence				
Knowledge	Students demonstrate basic knowledge	e and understanding of modeling, simulation	and analysis of comp	lex rigid and flexil
	multibody systems and methods for opti	imizing dynamic systems after successful com	pletion of the module.	
Skills	Students are able			
	+ to think holistically			
	+ to independently, securly and critica	Ily analyze and optimize basic problems of t	he dynamics of rigid a	nd flexible multibo
	systems			
	+ to describe dynamics problems mathe	ematically		
	+ to optimize dynamics problems			
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous grou	ups and to document the corresponding result	S.	
Autonomy	Students are able to			
	+ assess their knowledge by means of e	vercises		
	+ acquaint themselves with the necessa	ary knowledge to solve research oriented tasks	5.	
Workload in Hours	Independent Study Time 124, Study Tim	ne in Lecture 56		
Credit points				
Course achievement				
Examination				
Examination duration and	30 min			
scale				
Assignment for the	Energy Systems: Core qualification: Elec	tive Compulsory		
Following Curricula	Aircraft Systems Engineering: Core quali			
		tion Aircraft Systems: Elective Compulsory		
	Mechatronics: Specialisation System Des			
		Systems and Robotics: Elective Compulsory		
	Broduct Dovolopment Materials and Bro	duction Coro gualification. Flactive Communi-	P1/	
	Product Development, Materials and Pro Theoretical Mechanical Engineering: Cor	duction: Core qualification: Elective Compulso	ry	

Course L1632: Flexible Multi	Course L1632: Flexible Multibody Systems		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Robert Seifried, Dr. Alexander Held		
Language	DE		
Cycle	WiSe		
Content	 Basics of Multibody Systems Basics of Continuum Mechanics Linear finite element modelles and modell reduction Nonlinear finite element Modelles: absolute nodal coordinate formulation Kinematics of an elastic body Kinetics of an elastic body System assembly 		
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: Optimization	Course L1633: Optimization of dynamical systems	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Robert Seifried	
Language	DE	
Cycle	WiSe	
Content	 Formulation and classification of optimization problems Scalar Optimization Sensitivity Analysis Unconstrained Parameter Optimization Constrained Parameter Optimization Stochastic optimization Multicriteria Optimization Topology Optimization 	
Literature	Bestle, D.: Analyse und Optimierung von Mehrkörpersystemen. Springer, Berlin, 1994. Nocedal, J. , Wright , S.J. : Numerical Optimization. New York: Springer, 2006.	

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Module M1306: Contr	ol Lab C			
Courses				
Title		Тур	Hrs/wk	СР
Control Lab IX (L1836)		Practical Course	1	1
Control Lab VII (L1834)		Practical Course	1	1
Control Lab VIII (L1835)		Practical Course	1	1
	Prof. Herbert Werner			
•	None			
Recommended Previous	State space methods			
Knowledge	LQG control			
	H2 and H-infinity optimal control			
	uncertain plant models and robus	st control		
	LPV control			
Educational Objectives	After taking part successfully, students	have reached the following learning results		
Professional Competence				
Knowledge				- listation
	 Students can explain the different 	nce between validation of a control lop in simulation	n and experimental v	alldation
Skills				
	 Students are capable of applying 	ng basic system identification tools (Matlab Sys	tem Identification To	olbox) to identify
	dynamic model that can be used	for controller synthesis		
	 They are capable of using stand 	dard software tools (Matlab Control Toolbox) for	the design and imp	lementation of LQ
	controllers			
	 They are capable of using standard 	ard software tools (Matlab Robust Control Toolbox)) for the mixed-sensit	ivity design and th
	implementation of H-infinity optir	mal controllers		
	 They are capable of representing 	model uncertainty, and of designing and impleme	enting a robust contro	oller
	 They are capable of using standa 	ard software tools (Matlab Robust Control Toolbox)	for the design and th	e implementation of
	LPV gain-scheduled controllers			
Personal Competence				
Social Competence				
Social competence	Students can work in teams to co	onduct experiments and document the results		
Autonomy	• Students can independently carry	y out simulation studies to design and validate cor	ntrol loops	
		,j		
	Independent Study Time 48, Study Time	e in Lecture 42		
Credit points				
Course achievement				
	Written elaboration			
Examination duration and	1			
scale				
-		ontrol and Power Systems Engineering: Elective Co	ompulsory	
Following Curricula		Systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System De	sign: Elective Compulsory		
	Theoretical Mechanical Engineering: Con	re qualification: Elective Compulsory		

Course L1836: Control Lab I)	Course L1836: Control Lab IX	
Тур	Practical Course	
Hrs/wk	1	
СР	1	
Workload in Hours	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 V	Irse L1834: Control Lab VII	
Тур	Practical Course	
Hrs/wk	1	
СР	1	
Workload in Hours	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: Control Lab V	Course L1835: Control Lab VIII	
Тур	Practical Course	
Hrs/wk	1	
СР	1	
Workload in Hours	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	

Module M1150: Conti	nuum Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1	534)	Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught	, e.g., in the module Mechanics II (forces and	l moments, stres	s, linear strain, fre
Knowledge	body principle, linear-elastic constitutive laws, st	rain energy).		
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental conce	pts to calculate the mechanical behavior of m	naterials.	
Skills	The students can set up balance laws and appl	y basics of deformation theory to specific as	pects, both in a	pplied contexts as
	research contexts.			
Personal Competence				
Social Competence	The students are able to develop solutions, to pr	esent them to specialists in written form and	to develop ideas	further.
Autonomy	The students are able to assess their own streng	ths and weaknesses. They can independently	y and on their o	wn identify and sol
	problems in the area of continuum mechanics ar	d acquire the knowledge required to this end		
Workload in Hours	Independent Study Time 124, Study Time in Lec	ure 56		
Credit points				
Course achievement				
Examination				
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elect	ive Compulsory		
•	Mechanical Engineering and Management: Spec			
-	Mechatronics: Technical Complementary Course			
	Biomedical Engineering: Specialisation Artificial	Organs and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical T	echnology and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Managen	nent and Business Administration: Elective Co	mpulsory	
	Product Development, Materials and Production:	Core qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical C	omplementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualifi	cation: Elective Compulsory		

e L1533: Continuum Me	chanics	
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28	
	Prof. Christian Cyron	
Language		
Cycle	wise	
Content	Fundamentals of tensor calculus	
	 Transformation invariance 	
	Tensor algebra	
	Tensor analysis	
	Kinematics	
	Motion of continuum	
	 Deformation of infinitesimal line, area and volume elements 	
	 Material and spatial description 	
	Polar decomposition	
	Spectral decomposition	
	• Objectivity	
	Strain measures	
	 Time derivatives 	
	 Partial / material time derivatives 	
	 Objective time rates 	
	 Strain and deformation rates 	
	 Transport theorems 	
	Balance equations (global and local form)	
	Balance of mass	
	• The stress state	
	 Surface traction vectors 	
	Cauchy's fundamental theorem	
	 Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor) 	
	Balance of linear momentum	
	Balance of angular momentum Balance of anguru	
	 Balance of energy Balance of entropy 	
	Clausius-Duhem inequality	
	Constitutive laws	
	Constitutive assumptions	
	 Fluids 	
	• Elastic solids	
	 Hyperelasticity 	
	 Material symmetry 	
	 Elasto-plastic solids 	
	Analysis	
	 Initial-boundary value problems and their numerical solution 	
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker	
	I-S. Liu: Continuum Mechanics, Springer	
	weitere siehe in der Literaturliste des Scripts	

Course L1534: Continuum M	ourse L1534: Continuum Mechanics Exercise		
	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	 kinematics of undeformed and deformed bodies balance equations (balance of mass, balance of energy,) stress states material modelling 		
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer		

Module M0751: Vibra				
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusLinear AlgebraEngineering Mechanics			
Educational Objectives	After taking part successfully, students have reached	he following learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vib	ration Theory and develop them fu	rther.	
Skills	Students are able to denote methods of Vibration The	ory and develop them further.		
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research ta	sks in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Energy Systems: Core qualification: Elective Compulso	ry		
Following Curricula	International Management and Engineering: Specialisa	tion II. Mechatronics: Elective Comp	oulsory	
	Mechanical Engineering and Management: Specialisati	on Mechatronics: Elective Compulse	ory	
	Mechatronics: Core qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Electi	ve Compulsory	
	Biomedical Engineering: Specialisation Implants and E	ndoprostheses: Elective Compulsory	ý	
	Biomedical Engineering: Specialisation Medical Techno	logy and Control Theory: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Management a	nd Business Administration: Elective	e Compulsory	
	Product Development, Materials and Production: Core			
	Naval Architecture and Ocean Engineering: Core quality			
	Theoretical Mechanical Engineering: Technical Comple		ory	
	Theoretical Mechanical Engineering: Core qualification	: Elective Compulsory		

Course L0701: Vibration The	Course L0701: Vibration Theory		
Тур	Integrated Lecture		
Hrs/wk	4		
СР	6		
Workload in Hours	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.		

Courses					
Title	14	Тур	Hrs/wk	СР	
Numerical Treatment of Ordinary D Numerical Treatment of Ordinary D		Lecture Recitation Section (small)	2	3 3	
Module Responsible			_		
Admission Requirements					
Recommended Previous					
Knowledge		rende (deutsch oder englisch) oder Analysis & Li	neare Algebra I -	+ II sowie Analysis	
-	für Technomathematiker				
	Basic MATLAB knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results			
Professional Competence					
Knowledge	Students are able to				
	 list numerical methods for the colution 	of ordinary differential equations and explain the	oir coro idoac		
		the treated numerical methods (including the		d to the underly	
	problem),			,	
	 explain aspects regarding the practica 	l execution of a method.			
	 select the appropriate numerical me 	ethod for concrete problems, implement the r	numerical algorit	thms efficiently	
	interpret the numerical results				
Skills	Students are able to				
Skins					
		are numerical methods for the solution of ordinar			
		f numerical methods with respect to the posed p		÷	
		e solution approach, if necessary by the composi	tion of several al	gorithms, to exec	
	this approach and to critically evaluate	e the results.			
Personal Competence					
	Students are able to				
boelar competence					
		posed teams (i.e., teams from different study pr			
	explain theoretical foundations and su	pport each other with practical aspects regarding	, the implementa	tion of algorithms	
Autonomy	V Students are capable				
	• to preserve whether the supporting these	ratical and practical excercises are better celved	individually or in		
		retical and practical excercises are better solved , if necessary, to ask questions and seek help.	individually or in	a team,	
Workload in Hours	Independent Study Time 124, Study Time in I	Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 min				
scale					
-		neral Bioprocess Engineering: Elective Compulso			
Following Curricula		alisation Chemical Process Engineering: Elective C			
	Chemical and Bioprocess Engineering: Specia Computer Science: Specialisation III. Mathem	alisation General Process Engineering: Elective Co	mpulsory		
		and Power Systems Engineering: Elective Compu	ulsory		
	Energy Systems: Core qualification: Elective (, , , ,			
	Aircraft Systems Engineering: Core qualificati				
	, , ,	II. Numerical - Modelling Training: Compulsory			
	Mechatronics: Specialisation Intelligent Syste	ms and Robotics: Elective Compulsory			
	Technomathematics: Specialisation I. Mathen	natics: Elective Compulsory			
	Theoretical Mechanical Engineering: Core qua				
	Process Engineering: Specialisation Chemical				
	Process Engineering: Specialisation Process E	ngineering: Elective Compulsory			

Course L0576: Numerical Tre	ourse L0576: Numerical Treatment of Ordinary Differential Equations		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	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	 E. Hairer, S. Noersett, G. Wanner: Solving Ordinary Differential Equations I: Nonstiff Problems E. Hairer, G. Wanner: Solving Ordinary Differential Equations II: Stiff and Differential-Algebraic Problems 		

Course L0582: Numerical Tre	ourse L0582: Numerical Treatment of Ordinary Differential Equations	
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	3	
Workload in Hours	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 M1203: Appli	ed Dynamics: Nu	merical and ex	perimental met	thods		
Co						
Courses			.		Hue fools	CD
Title Lab Applied Dynamics (L1631)			Ty	p ictical Course	Hrs/wk 3	СР 3
Applied Dynamics (L1630)				ture	2	3
Module Responsible	Prof. Robert Seifried					
Admission Requirements						
Recommended Previous	Mathematics I, II, III, Me	chanics I, II, III, IV				
Knowledge	Numerical Treatment of	Ordinany Differential F	quations			
Educational Objectives	Numerical Treatment of			aarning results		
Professional Competence	Arter taking part succes	situity, students have n	cachea the following is			
	Students can represent	the most important n	nethods of dynamics a	after successful com	pletion of the module	Technical dynami
	and have a good unders					
<i>CL 11</i>						
SKIIIS	Students are able					
	+ to think holistically					
	+ to independently, se	curly and critically an	alvze and optimize ba	asic problems of the	dynamics of rigid ar	nd flexible multibo
	systems	, , , , , , , , , , , , , , , , , , ,	,		, , , , , , , , , , , , , , , , , , ,	
			- 11			
	+ to describe dynamics	problems mathematic	ally			
	+ to investigate dynam	ics problems both expe	erimentally and numer	ically		
Personal Competence						
	Students are able to					
	, salus makiana in kat					
	+ solve problems in het	erogeneous groups an	a to document the cor	responding results.		
Autonomy	Students are able to					
	+ assess their knowledg	ge by means of exercis	es and experiments.			
	+ acquaint themselves	with the necessary kno	wledge to solve resea	rch oriented tasks.		
Workload in Hours	Independent Study Time	e 110, Study Time in Le	ecture 70			
Credit points						
Course achievement		Form Subject theoretical	Description andVersuche Fachlal	oor		
		practical work	and versuche racfild	501		
Examination	Written exam					
Examination duration and	90 min					
scale						
Assignment for the	Theoretical Mechanical	Engineering: Core qual	ification: Compulsory			
Following Curricula						

Course L1631: Lab Applied D	ynamics
Тур	Practical Course
Hrs/wk	3
СР	3
Workload in Hours	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 11020, Annihol Duno	
Course L1630: Applied Dyna	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	SoSe
Content	 Modelling of Multibody Systems Basics from kinematics and kinetics Constraints Multibody systems in minimal coordinates State space, linearization and modal analysis Multibody systems with kinematic constraints Multibody systems as DAE Non-holonomic multibody systems Experimental Methods in Dynamics
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: Nonli	near Dynamics			
Courses				
Title Nonlinear Dynamics (L0702)		Typ Integrated Lecture	Hrs/wk 4	CP 6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	 Calculus Linear Algebra Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
	Students are able to reflect existing terms and co concepts.		·	
Personal Competence	Students are able to apply existing methods and pro	besures of Nonlinear Dynamics and to	develop novel metr	ious and procedure
	Students can reach working results also in groups.			
	Students are able to approach given research tasks	individually and to identify and follow	up novel research ta	sks by themselves
	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
	Written exam			
Examination duration and scale				
Assignment for the	Aircraft Systems Engineering: Core qualification: Ele	ctive Compulsory		
Following Curricula	International Management and Engineering: Special	isation II. Mechatronics: Elective Comp	oulsory	
	Mechanical Engineering and Management: Specialis	ation Mechatronics: Elective Compulso	ory	
	Mechatronics: Specialisation System Design: Electiv	e Compulsory		
	Mechatronics: Specialisation Intelligent Systems and	Robotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Org	•		
	Biomedical Engineering: Specialisation Implants and			
	Biomedical Engineering: Specialisation Medical Tech			
	Biomedical Engineering: Specialisation Managemen Product Development, Materials and Production: Co		compulsory	
	Theoretical Mechanical Engineering: Technical Com		rv	
	Theoretical Mechanical Engineering: Core qualificati		.,	

Course L0702: Nonlinear Dyr	Course L0702: Nonlinear Dynamics	
Тур	Integrated Lecture	
Hrs/wk	4	
СР	6	
Workload in Hours	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				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Ident	fication (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Classical control (frequency response)	onse, root locus)		
	State space methodsDiscrete-time systems			
	 Discrete-time systems Linear algebra, singular value dec 	composition		
	 Basic knowledge about stochastic 			
Educational Objectives	After taking part successfully, students I	have reached the following learning results		
Professional Competence				
Knowledge	. Students can explain the genera	I framework of the prediction error method	and its application to a	variaty of linear a
	 Students can explain the general nonlinear model structures 	I framework of the prediction error method a	and its application to a	variety of liftear a
		perceptron networks are used to model nonlin	ear dynamics	
		mate predictive control scheme can be based		ls
		pace identification and its relation to Kalman		5
			,	
Skills	 Students are canable of applying 	g the predicition error method to the experi	mental identification of	linear and nonline
	models for dynamic systems			
		g a nonlinear predictive control scheme based	on a neural network mo	del
		space algorithms to the experimental identific		
		ndard software tools (including the Matlab Syst		
Personal Competence		· · · · · · · · · · · · · · · · · · ·		
Social Competence	Students can work in mixed groups on s	pecific problems to arrive at joint solutions.		
Autonomy	Students are able to find required inform	nation in sources provided (lecture notes, liter	ature, software docume	ntation) and use it
	solve given problems.			
Westleed in Herrie		in Lookura 20		
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and	30 min			
scale	Flashring Frazingeningen Crassic lighting Co		Commulation	
		ntrol and Power Systems Engineering: Elective	e Compulsory	
Following Curricula	Mechatronics: Specialisation Intelligent	Systems and Robotics: Elective Compulsory		
		Artificial Organs and Regenerative Medicine: El	lective Compulsory	
	5 5 1	mplants and Endoprostheses: Elective Computer	1 3	
	• • •	Medical Technology and Control Theory: Comp	-	
	• • •	Anagement and Business Administration: Electrony		
		chnical Complementary Course: Elective Comp		
	Theoretical Mechanical Engineering: Cor		-	

Course L0660: Linear and No	onlinear System Identification
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	 Prediction error method Linear and nonlinear model structures Nonlinear model structure based on multilayer perceptron network Approximate predictive control based on multilayer perceptron network model Subspace identification
Literature	 Lennart Ljung, System Identification - Theory for the User, Prentice Hall 1999 M. Norgaard, O. Ravn, N.K. Poulsen and L.K. Hansen, Neural Networks for Modeling and Control of Dynamic Systems, Springer Verlag, London 2003 T. Kailath, A.H. Sayed and B. Hassibi, Linear Estimation, Prentice Hall 2000

Courses					
Title		Тур	Hrs/wk	СР	
Computational Fluid Dynamics II (L	0237)	Lecture	2	3	
Computational Fluid Dynamics II (L		Recitation Section (large)	2	3	
Module Responsible	Prof. Thomas Rung				
Admission Requirements	None				
Recommended Previous	Basics of computational and general the	rmo/fluid dynamics			
Knowledge					
Educational Objectives	After taking part successfully, students h	ave reached the following learning results			
Professional Competence					
Knowledge	Establish a thorough understanding of Fi	nite-Volume approaches. Familiarise with details of	the theoretical ba	ckground of comp	
	CFD algorithms.				
CI-III-		and build up of andian shills. Ability to such the			
SKIIIS	s Ability to manage of interface problems and build-up of coding skills. Ability to evaluate, assess and benchmark different soluti				
	options.				
Personal Competence					
•	Practice of team working during team ex	ercises			
	Indenpendent analysis of specific solution				
	Independent Study Time 124, Study Time				
Credit points					
Course achievement					
Examination	Oral exam				
Examination duration and					
scale					
Assignment for the	Energy Systems: Core qualification: Elect	tive Compulsory			
-		ng: Core qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Tecl	hnical Complementary Course: Elective Compulsory	1		
	Theoretical Mechanical Engineering: Core	e qualification: Elective Compulsory			

Course L0237: Computationa	Il 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: Computationa	ourse 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						
		T	Hara (anda	CP		
Fitle Optimal and Robust Control (L0658		Typ Lecture	Hrs/wk 2	CP 3		
Optimal and Robust Control (L0659		Recitation Section (small)	2	3		
Module Responsible	Prof. Herbert Werner					
Admission Requirements						
Recommended Previous						
Knowledge	 Classical control (frequency response, root locus) 					
-	State space methods					
	Linear algebra, singular value decomposition					
Educational Objectives	After taking part successfully, students have reached the f	ollowing learning results				
Professional Competence						
Knowledge						
	Students can explain the significance of the matrix I					
	• They can explain the duality between optimal state	·				
	• They can explain how the H2 and H-infinity norms a					
	 They can explain how an LQG design problem can b They can explain how model uncertainty can be rep 		5 1			
	 They can explain how model uncertainty can be rep They can explain how - based on the small gain the 			÷		
	an uncertain plant.		arantee stability			
	 They understand how analysis and synthesis conditi 	ons on feedback loops can be repr	esented as linear	matrix inequaliti		
	,					
Skills	 Students are capable of designing and tuning LQG c 	ontrollers for multivariable plant m	odels.			
	 They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standa 					
	software tools for solving it.					
	• They are capable of translating time and frequency	domain specifications for control	loops into const	raints on closed-		
	sensitivity functions, and of carrying out a mixed-sensitivity design.					
	• They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-object					
	robust controller.					
	 They are capable of formulating analysis and synth 	esis conditions as linear matrix ine	qualities (LMI), a	nd of using stand		
	LMI-solvers for solving them.					
	 They can carry out all of the above using standard s 	oftware tools (Matlab robust contro	ol toolbox).			
Personal Competence						
	Students can work in small groups on specific problems to	arrive at joint solutions.				
	Students are able to find required information in sources p		software docume	ntation) and use		
,	solve given problems.			·		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56					
Credit points	6					
Course achievement	None					
Examination	Oral exam					
Examination duration and	30 min					
scale						
			1			
•	Electrical Engineering: Specialisation Control and Power Sy	stems Engineering: Elective Comp	uisory			
Following curricula	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Compulsory					
	Mechatronics: Specialisation Intelligent Systems and Robot					
	Mechatronics: Specialisation System Design: Elective Com					
	Biomedical Engineering: Specialisation Artificial Organs and	•	Compulsory			
	Biomedical Engineering: Specialisation Implants and Endog	-				
	Biomedical Engineering: Specialisation Medical Technology		pulsory			
	Biomedical Engineering: Specialisation Management and B					
	Product Development, Materials and Production: Specialisa	tion Product Development: Elective	e Compulsory			
	Product Development, Materials and Production: Specialisa	tion Production: Elective Compulso	ory			
	Product Development, Materials and Production: Specialisa	tion Materials: Elective Compulsor	y			
	Theoretical Mechanical Engineering: Technical Complement	tary Course: Elective Compulsory				
	Theoretical Mechanical Engineering: Core qualification: Ele	ctive Compulsory				

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

Course L0659: Optimal and F	Course L0659: Optimal and Robust 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	SoSe				
Content	See interlocking course				
Literature	See interlocking course				

	Тур	Hrs/wk	СР
ic Approaches in Structural Analysis (L1873)	Lecture	2	3
ic Approaches in Structural Analysis (L1874)	Recitation Section (large)	2	3
Prof. Benedikt Kriegesmann			
None			
The state of the state of the			
Higher math			
After taking part successfully, students have reached	the following learning results		
• •			
 Coupling of design optimization and reli 	ability analysis		
	babilistic methods in the design of struct	ures	
Debugging			
Team work			
Oral explanation of the the work			
 Application of methods learned in the framework 	ork of a home work		
 Familiarizing with source code provided 			
 Description of approaches and results 			
Independent Study Time 124, Study Time in Lecture	56		
to payes			
	ic Approaches in Structural Analysis (L1874) Prof. Benedikt Kriegesmann None	ic Approaches in Structural Analysis (L1873) ic Approaches in Structural Analysis (L1874) Prof. Benedikt Kriegesmann None • Technical mechanics • Higher math After taking part successfully, students have reached the following learning results • Design optimization • Gradient based methods • 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 • Application of optimization and reliability analysis • Application of optimization algorithms and probabilistic methods in the design of struct • Programming with Matlab • Implementation of algorithms • Debugging • Team work • Oral explanation of the the work • Application of methods learned in the framework of a home work • Familiarizing with source code provided • Description of approaches and results Independent Study Time 124, Study Time in Lecture 56 6 None Written elaboration	ic Approaches in Structural Analysis (L1873) Lecture 2 Prof. Benedikt Kriegesmann None

Course L1873: Design Optim	ization and Probabilistic Approaches in Structural Analysis
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	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	 Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011. Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley & Sons New York/Chichester, UK, 2000.

Course L1874: Design Optim	Course L1874: Design Optimization and Probabilistic Approaches in Structural Analysis				
Тур	Recitation Section (large)				
Hrs/wk	2				
СР	3				
Workload in Hours	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				

Module M0604: High-	Order FEM					
-						
Courses						
Title				Тур	Hrs/wk	СР
High-Order FEM (L0280) High-Order FEM (L0281)				Lecture Recitation Section (large)	3 1	4 2
Module Responsible	Prof Alexander Düs	ter		neenation beetion (large)		-
Admission Requirements	None					
Recommended Previous		l differential equations i	is recommended			
Knowledge	internedge of partia					
Educational Objectives	After taking part suc	ccessfully, students hav	e reached the following	g learning results		
Professional Competence	51			5		
	Students are able to)				
J.		of the different (h, p, hp) finite element proce	dures.		
	+ explain high-orde	r finite element procedu	ires.			
	+ specify problems	of finite element proc	edures, to identify th	em in a given situation a	nd to explain the	ir mathematical ar
	mechanical backgro	und.				
Skills	Students are able to)				
	+ apply high-order f	inite elements to proble	ems of structural mech	anics.		
	+ select for a given	problem of structural m	nechanics a suitable fir	ite element procedure.		
	+ critically judge res	sults of high-order finite	elements.			
	+ transfer their know	wledge of high-order fin	ite elements to new pr	roblems.		
Personal Competence						
	Students are able to)				
	+ solve problems in	heterogeneous groups	and to document the o	corresponding results.		
4						
Autonomy	Students are able to) ledge by means of exer	cises and E-Learning			
		ves with the necessary		search oriented tasks		
Workload in Hours	Independent Study	Time 124, Study Time in	n Lecture 56			
Credit points	6					
Course achievement	Compulsory Bonus	Form Presentation	Description Forschendes L	ernen		
Fxamination	Written exam	resentation	i orschendes L	enten		
Examination duration and						
scale						
Assignment for the	Energy Systems: Co	re qualification: Elective	e Compulsory			
-				luct Development and Prod	uction: Elective Co	ompulsory
	Materials Science: S	pecialisation Modeling:	Elective Compulsory			
	Mechanical Enginee	ring and Management:	Specialisation Product	Development and Production	on: Elective Comp	ulsory
	Mechatronics: Techr	nical Complementary Co	ourse: Elective Compul	sory		
		nt, Materials and Produc				
		and Ocean Engineering:				
		: Specialisation III. Engi	5	1 3		
		ical Engineering: Techni ical Engineering: Core q		ourse: Elective Compulsory		
	mediencal Mechani	car Engineering: Core q		ompulsory		

Тур	Lecture			
Hrs/wk	3			
CP	4			
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42			
Lecturer	Prof. Alexander Düster			
Language	EN			
Cycle	SoSe			
Content	1. Introduction			
	2. Motivation			
	3. Hierarchic shape functions			
	4. Mapping functions			
	5. Computation of element matrices, assembly, constraint enforcement and solution			
	6. Convergence characteristics			
	7. Mechanical models and finite elements for thin-walled structures			
	8. Computation of thin-walled structures			
	9. Error estimation and hp-adaptivity			
	10. High-order fictitious domain methods			
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 FE	ourse L0281: High-Order FEM		
Тур	Recitation Section (large)		
Hrs/wk	1		
CP	2		
Workload in Hours	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		

Courses				
Title		Тур	Hrs/wk	СР
Numerical Mathematics II (L0568)		Lecture	2	3
Numerical Mathematics II (L0569)		Recitation Section (small)	2	3
Module Responsible	Prof. Sabine Le Borne			
Admission Requirements	None			
Recommended Previous	Numerical Mathematics I			
Knowledge	Python knowledge			
	• Fython knowledge			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	 name advanced numerical methods 	for interpolation, approximation, integra	ion eigenvalue r	oroblems eigenval
	problems, nonlinear root finding proble		lion, eigenvalue j	librosienis, eigenvar
		numerical methods, sketch convergence pro	ofs.	
		methods concerning runtime and storage nee		
		al implementation of numerical methods wit		utational and stora
	complexity.			
Skills	Students are able to			
JKIIIS				
	 implement, apply and compare advance 	ed numerical methods in Python,		
	 justify the convergence behaviour of n 	umerical methods with respect to the proble	m and solution alg	prithm and to transf
	it to related problems,			
		ble solution approach, if necessary through	n composition of s	everal algorithms,
	execute this approach and to critically	evaluate the results		
Personal Competence				
Social Competence	Students are able to			
	 work together in beterogeneously com 	posed teams (i.e., teams from different study	programs and ba	skaround knowledge
		port each other with practical aspects regard		
			ing the implement	
Autonomy	Students are capable			
	 to assess whether the supporting theor 	retical and practical excercises are better solv	ved individually or i	n a team,
		if necessary, to ask questions and seek help.	,	
No. 11 11 11				
	Independent Study Time 124, Study Time in L	ecture 56		
Credit points Course achievement				
Examination				
Examination Examination duration and				
examination duration and scale				
	Computer Science: Specialisation III. Mathema	atics: Elective Compulsory		
Following Curricula	Computational Science and Engineering: Specialisation		prv	
g eachedia	Technomathematics: Specialisation I. Mathem			
	Theoretical Mechanical Engineering: Technica	1 2	У	
	Theoretical Mechanical Engineering: Core gua		-	

Course L0568: Numerical Ma	thematics II
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	SoSe
Content	 Error and stability: Notions and estimates Rational interpolation and approximation Multidimensional interpolation (RBF) and approximation (neural nets) Quadrature: Gaussian quadrature, orthogonal polynomials Linear systems: Perturbation theory of decompositions, structured matrices Eigenvalue problems: LR-, QD-, QR-Algorithmus Nonlinear systems of equations: Newton and Quasi-Newton methods, line search (optional) Krylov space methods: Arnoldi-, Lanczos methods (optional)
Literature	 Skript Stoer/Bulirsch: Numerische Mathematik 1, Springer Dahmen, Reusken: Numerik f ür Ingenieure und Naturwissenschaftler, Springer

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

Courses				
Title		Тур	Hrs/wk	СР
Stochastics (L0777) Stochastics (L0778)		Lecture Recitation Section (small)	2 2	4 2
Module Responsible	Prof. Matthias Schulte	Necleation Section (Smail)	2	L
Admission Requirements	None			
Recommended Previous				
Knowledge	Calculus			
-	Discrete algebraic structures (combinatorics)			
	Propositional logic			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	 Students can name the basic concepts in Stoch 	actics. They are able to explain them us	ing appropriate	examples
	 Students can have the basic concepts in stort Students can discuss logical connections betw 			
	the help of examples.	they are concepts. They are capable	or muscrating ti	
	They know proof strategies and can reproduce	them.		
<i></i>				
Skills	 Students can model problems from stochastic 	s with the help of the concepts studie	d in this course	e. Moreover, they a
	capable of solving them by applying establishe	d methods.		
	Students are able to discover and verify further	logical connections between the conce	pts studied in th	e course.
	 For a given problem, the students can develop 	p and execute a suitable approach, a	nd are able to d	ritically evaluate the
	results.			
Personal Competence				
Social Competence				
	 Students are able to work together (e.g. on the different study programs and background know 			
	 In doing so, they can communicate new conce 			
	design examples to check and deepen the und		for a ling particle.	. Moreover, they ee
Autonomy	 Students are capable of checking their unders 	tanding of complex concepts on their o	wn. They can sr	pecify open question
	precisely and know where to get help in solving			
	 Students can put their knowledge in relation to 	the contents of other lectures.		
	 Students have developed sufficient persistence 	e to be able to work for longer period	s in a goal-orier	nted manner on har
	problems.			
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	120 min			
scale				
•	General Engineering Science (German program, 7 ser	nester): Specialisation Computer Science	e: Compulsory	
Following Curricula	Computer Science: Core qualification: Compulsory			
	Data Science: Core qualification: Compulsory Computational Science and Engineering: Core qualific	ation: Compulsory		
	Logistics and Mobility: Specialisation Engineering Scie			
	Logistics and Mobility: Specialisation Information Tech			
	Theoretical Mechanical Engineering: Core qualification			
	Engineering and Management - Major in Logistics and		hoology: Electiv	Compulsory

Course L0777: Stochastics	
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Matthias Schulte
Language	DE/EN
Cycle	SoSe
Content	 Definitions of probability, conditional probability Random variables, dependencies, independence assumptions, Marginal and joint probabilities Distributions and density functions Characteristics: expected values, variance, standard deviation, moments Multivariate distributions Law of large numbers and central limit theorem Basic notions of stochastic processes Basic concepts of statistics (point estimators, confidence intervals, hypothesis testing)
Literature	 Methoden der statistischen Inferenz, Likelihood und Bayes, Held, L., Spektrum 2008 Stochastik für Informatiker, Dümbgen, L., Springer 2003 Statistik: Der Weg zur Datenanalyse, Fahrmeir, L., Künstler R., Pigeot, I, Tutz, G., Springer 2010 Stochastik, Georgii, HO., deGruyter, 2009 Probability and Random Processes, Grimmett, G., Stirzaker, D., Oxford University Press, 2001 Programmieren mit R, Ligges, U., Springer 2008

Course L0778: Stochastics	ourse L0778: Stochastics		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Matthias Schulte		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Title Typ Hrs/wk CP Module Responsible Dozenten des SD M Admission Requirements None Recommended Previous Knowledge • Finite-element-methods • Control systems theory and design • Applied dynamics • Numerics of ordinary differential equations • Finite-element-methods • Control systems theory and design • Applied dynamics • Numerics of ordinary differential equations • Vumerics of ordinary differential equations Educational Objectives After taking part successfully, students have reached the following learning results • Professional Competence Knowledge Verify the state of technology and application and discuss critically in the context of actual problems and general conditions science and society. The students can develop solving strategies and approaches for fundamental and practical problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view point of science and society. Skills The students are able to independently select methods for the project work and to justify this choice. They can explain how the methods relate to the field of work and how the context of application has to be adjusted. General findings and furt developments may essentially be outlined. Skills The students are able to condense the relevance and the structur	Courses					
Module Responsible Dozenten des SD M Admission Requirements None Recommende Previous Finite-element-methods Control systems theory and design control systems theory and application and discuss critically in the context of actual problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view pol of science and society. Skills: The students are able	Title	Typ Hrs/wk CP				
Recommended Previous Knowledge Finite-element-methods Control systems theory and design Applied dynamics Numerics of ordinary differential equations Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence Knowledge The students are able to demonstrate their detailed knowledge in the field of theoretical mechanical engineering. They version and objectives Attention objectives The students are able to demonstrate their detailed knowledge in the field of theoretical mechanical engineering. They were applify the state of technology and application and discuss critically in the context of actual problems and general conditions science and society. The students can develop solving strategies and approaches for fundamental and practical problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view poil of science and society. Skills The students are able to independently select methods for the project work and to justify this choice. They can explain how the methods relate to the field of work and how the context of application has to be adjusted. General findings and furt developmeterce Social Competence The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback o	Module Responsible					
Knowledge Finite-element-methods Control systems theory and design Applied dynamics Numerics of ordinary differential equations Educational Objectives Arter taking part successfully, students have reached the following learning results Professional Competence Knowledge The students are able to demonstrate their detailed knowledge in the field of theoretical mechanical engineering. They or exemptify the state of technology and application and discuss critically in the context of actual problems and general conditions criterice and society. The students can develop solving strategies and approaches for fundamental and practical problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view poling strategies and approaches for fundamental and practical problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view poling of science and society. Scientfic 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 the methods relate to the field of work and how the context of application has to be adjusted. General findings and furt developments may essentially be outlined. Personal Competence The students are capable of independent year ore and the structure of the project work, the work steps	Admission Requirements	None				
Knowledge • Control systems theory and design • Applied dynamics • Numerics of ordinary differential equations Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence It is students are able to demonstrate their detailed knowledge in the field of theoretical mechanical engineering. They of exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions science and society. The students can develop solving strategies and approaches for fundamental and practical problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view point 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 the methods relate to the field of work and how the context of application has to be adjusted. General findings and furt developments may essentially be outlined. Personal Competence The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to the colleagues. Social Competence Independent Study Time 360, Study Time 1 Lecture 0 Workload in Hours Independent Study Time 360, Study Time 1 Lectu	Recommended Previous					
• Applied dynamics • Numerics of ordinary differential equations Educational Objectives Attertaking 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 of exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions science and society. The students can develop solving strategies and approaches for fundamental and practical problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view point of science and society. Scientific work techniques that are used can be described and critically reviewed. Personal Competence The students are able to independently select methods for the project work and to justify this choice. They can explain how the methods relate to the field of work and how the context of application has to be adjusted. General findings and furt developments may essentially be outlined. Personal Competence The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems in the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to colleagues. Autonom The students are capable of independently planning and documenting the work steps and procedures while considering the give deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can o	Knowledge					
e Numerics of ordinary differential equations Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence Interstance Knowledge The students are able to demonstrate their detailed knowledge in the field of theoretical mechanical engineering. They desemptify the state of technology and application and discuss critically in the context of actual problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view poil 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 the methods relate to the field of work and how the context of application has to be adjusted. General findings and furt developments may essentially be outlined. Personal Competence The students are able to condense the relevance and the structure of the project work, the work steps and procedures while considering the gin developments may essentially be outlined. Autonomy The students are capable of independently planning and documenting the work steps and procedures while considering the gin deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedbig from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology from experts with regard to the progress of the work, and to accomplish results on the state o						
Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence Instruction of the students are able to demonstrate their detailed knowledge in the field of theoretical mechanical engineering. They were mempify the state of technology and application and discuss critically in the context of actual problems and general conditions science and society. The students can develop solving strategies and approaches for fundamental and practical problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view poil 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 the methods relate to the field of work and how the context of application has to be adjusted. General findings and furt developments may essentially be outlined. Personal Competence Social Competence Social Competence The students are able to independently planning and documenting the work steps and procedures while considering the gin deadines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedba from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology Workload in Hours Independent Study Time in Lecture 0 Course achievement None						
Professional Competence Knowledge The students are able to demonstrate their detailed knowledge in the field of theoretical mechanical engineering. They dexemplify the state of technology and application and discuss critically in the context of actual problems and general conditions science and society. The students can develop solving strategies and approaches for fundamental and practical problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view point 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 the methods relate to the field of work and how the context of application has to be adjusted. General findings and furt developments may essentially be outlined. Personal Competence The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to the colleagues. Autonomy The students are capable of independently planning and documenting the work steps and procedures while considering the giving 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 and budy work Examination Study work		Numerics of ordinary differential equations				
Knowledge The students are able to demonstrate their detailed knowledge in the field of theoretical mechanical engineering. They are semplify the state of technology and application and discuss critically in the context of actual problems and general conditions science and society. The students can develop solving strategies and approaches for fundamental and practical problems in theoretical mechanical engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view point 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 the methods relate to the field of work and how the context of application has to be adjusted. General findings and furt developments may essentially be outlined. Personal Competence Social Competence Social Competence The students are capable of independently planning and documenting the work steps and procedures while considering the gin deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedber from experts with regard to the progress of the work, and to accomplish results on the state of the attein technology Workload In Hour Independent Sudy Time in Lecture 0 Latonomm Independent Sudy Time is 0. Study Time in Lecture 0 Latonomm Independent Sudy Time 360, Study Time in Lecture 0 Lourse achievement None	Educational Objectives	After taking part successfully, students have reached the following learning results				
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	-	Ineoretical Mechanical Engineering: Core qualification: Compulsory				

Module Responsible F Admission Requirements M Recommended Previous M Knowledge	s and Mechanics in Autonomous Driving (L1981) Prof. Robert Seifried None Mechanics IV, Applied Dynamics or Robotics Numerical Treatment of Ordinary Differential Equations	Typ Project-/problem-based Learning	Hrs/wk 2	CP 6	
Admission Requirements Recommended Previous Knowledge	None Mechanics IV, Applied Dynamics or Robotics				
Admission Requirements Recommended Previous Knowledge	None Mechanics IV, Applied Dynamics or Robotics				
Recommended Previous Knowledge	Mechanics IV, Applied Dynamics or Robotics				
Knowledge ۲					
	Control Systems Theory and Design				
Educational Objectives	After taking part successfully, students have reached th	e following learning results			
Professional Competence					
-	e After successful completion of the module students demonstrate deeper knowledge and understanding in selected application areas of multibody dynamics and robotics				
Skills S	Students are able				
-	+ to think holistically				
	+ to independently, securly and critically analyze and systems	l optimize basic problems of the dynami	cs of rigid ar	d flexible multibo	
-	+ to describe dynamics problems mathematically				
-	+ to implement dynamical problems on hardware				
Personal Competence					
Social Competence	Students are able to				
-	+ solve problems in heterogeneous groups and to docu	ment the corresponding results and prese	ent them		
Autonomy S	Students are able to				
-	+ assess their knowledge by means of exercises and p	ojects.			
-	+ acquaint themselves with the necessary knowledge t	o 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 T scale	ТВА				
Assignment for the	Mechatronics: Specialisation Intelligent Systems and Ro	botics: Elective Compulsory			
Following Curricula	Mechatronics: Specialisation System Design: Elective C	ompulsory			
г	Theoretical Mechanical Engineering: Technical Compler	nentary Course: Elective Compulsory			

Course L1981: Formulas and	Vehicles - Mathematics and Mechanics in Autonomous Driving	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	6	
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28	
Lecturer	Prof. Robert Seifried, Daniel-André Dücker	
Language	DE	
Cycle	WiSe	
Content		
Literature	Seifried, R.: Dynamics of underactuated multibody systems, Springer, 2014	
	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: Applied Statistics

Courses					
Title			Тур	Hrs/wk	СР
Applied Statistics (L1584)			Lecture	2	3
Applied Statistics (L1586)			Project-/problem-based Learning	2	2
Applied Statistics (L1585)	1		Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous	Basic knowledge of st	atistical methods			
Knowledge					
Educational Objectives	After taking part succ	essfully, students have re	ached the following learning results		
Professional Competence					
Knowledge	Students can explain	he statistical methods ar	d the conditions of their use.		
Skills	Students are able to u	se the statistics program	to solve statistics problems and to interpret and	depict the res	sults
Personal Competence					
Social Competence	Team Work, joined presentation of results				
4	To understand and interpret the question and solve				
Autonomy	To understand and im	erpret the question and s	olve		
Workload in Hours	Independent Study Ti	ne 110, Study Time in Le	cture 70		
Credit points	6				
Course achievement	Compulsory Bonus	Form	Description		
	Yes None	Written elaboration			
Examination	Written exam				
Examination duration and	90 minutes, 28 questi	ons			
scale					
Assignment for the	Mechanical Engineeri	ig and Management: Spe	cialisation Management: Elective Compulsory		
Following Curricula	Mechatronics: Special	sation System Design: El	ective Compulsory		
	Mechatronics: Special	sation Intelligent System	s and Robotics: Elective Compulsory		
	Biomedical Engineerir	g: Core qualification: Cor	npulsory		
	Product Development	Materials and Production	a: Core qualification: Elective Compulsory		
	Theoretical Mechanica	I Engineering: Technical	Complementary Course: Elective Compulsory		
	Theoretical Mechanica	I Engineering: Specialisa	ion Bio- and Medical Technology: Elective Comp	ulsory	

Course L1584: Applied Statis			
	Lecture		
Hrs/wk			
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Michael Morlock		
Language	DE/EN		
Cycle	WiSe		
Content	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		
	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 Statis	stics
Тур	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	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 Statis	stics
Тур	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	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

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Courses				
Title		Typ Lecture	Hrs/wk 2	СР 3
Biomaterials (L0593) Module Responsible	Drof Michael Marlack	Lecture	Z	3
Admission Requirements				
	Basic knowledge of orthopedic and su	raical techniques is recommended		
Knowledge	basic knowledge of orthopedic and su			
5	After taking part successfully, student	s have reached the following learning results		
Professional Competence				
Knowledge	The students can describe the materia use.	ls of the human body and the materials being u	used in medical engineer	ing, and their fields
Skills	The students can explain the advanta	ges and disadvantages of different kinds of bion	naterials.	
Personal Competence				
Social Competence	The students are able to discuss issue the teachers.	es related to materials being present or being us	sed for replacements wit	h student mates a
Autonomy	The students are able to acquire inform	nation on their own. They can also judge the inf	formation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Tir	ne in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engine	ering: Specialisation II. Process Engineering and	Biotechnology: Elective	Compulsory
Following Curricula		and Hybrid Materials: Elective Compulsory		
		Artificial Organs and Regenerative Medicine: E	lective Compulsory	
	• • •	Implants and Endoprostheses: Compulsory		
		Medical Technology and Control Theory: Electiv		
		Management and Business Administration: Ele		
	5 5	echnical Complementary Course: Elective Comp	,	
	Theoretical Mechanical Engineering: S	pecialisation Bio- and Medical Technology: Elect	tive Compulsory	

Course L0593: Biomaterials	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	
Cycle	
Content	Topics to be covered include: 1. Introduction (Importance, nomenclature, relations)
	 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
	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.
Literature	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.
	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. Berlin, Springer, 1996.

Courses				
Title		Тур	Hrs/wk	СР
Bioelectromagnetics: Principles and	Applications (L0371)	Lecture	3	5
Bioelectromagnetics: Principles and	Applications (L0373)	Recitation Section (small)	2	1
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous	Basic principles of physics			
Knowledge				
Educational Objectives	After taking part successfully, students ha	we reached the following learning results		
Professional Competence				
Knowledge	Students can explain the basic principles,	relationships, and methods of bioelectromagnet	ics, i.e. the quantific	ation and applicat
	of electromagnetic fields in biological tiss	sue. They can define and exemplify the most in	nportant physical pl	henomena and or
	them corresponding to wavelength and	frequency of the fields. They can give an ove	rview over measure	ment and numeri
	techniques for characterization of electro	pmagnetic fields in practical applications . They	can give examples	s for therapeutic a
	diagnostic utilization of electromagnetic fi	elds in medical technology.		
Skills	Students know how to apply various meth	ods to characterize the behavior of electromagn	etic fields in biologic	al tissue. In orde
	do this they can relate to and make use	of the elementary solutions of Maxwell's Equa	tions. They are able	e to assess the m
	important effects that these models pre	dict for biological tissue, they can order the e	ffects corresponding	g to wavelength a
	frequency, respectively, and they can and	alyze them in a quantitative way. They are able	to develop validatio	n strategies for th
	predictions. They are able to evaluate the	effects of electromagnetic fields for therapeutic	and diagnostic appl	ications and make
	appropriate choice.			
Personal Competence				
Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively			
	English (e.g. during small group exercises).		
Autonomy		tion from subject related, professional publicat		
		nake a connection between their knowledge ob		
		gnetic fields, fundamentals of electrical engine	ering / physics). The	ey can communic
	problems and effects in the field of bioele	ctromagnetics in English.		
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70		
Credit points				
Course achievement	Compulsory Bonus Form	Description		
	Yes None Presentation			
Examination	Oral exam			
Examination duration and	45 min			
scale				
Acatanana at ta at	Electrical Engineering: Countriller the still	awaya Engineering, Onting, and Start and a	Compatibility 51	ive Correction
Assignment for the		owave Engineering, Optics, and Electromagnetic	compatibility: Elect	ive compulsory
Following Curricula	Electrical Engineering: Specialisation Medi		Computerer:	
	• •	ig: Specialisation II. Electrical Engineering: Electi		
		tificial Organs and Regenerative Medicine: Electi		
	• • •	nagement and Business Administration: Elective		
		edical Technology and Control Theory: Elective C		
	• • •	plants and Endoprostheses: Elective Compulsory		
		ialisation Bio- and Medical Technology: Elective	Compulsons	

Тур	Lecture
Hrs/wk	
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	
Content	- 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
	- Behavior of electromagnetic fields of low frequency in biological tissue
	- 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
Literature	- 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)
	- 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: Bioelectromag	ourse L0373: Bioelectromagnetics: Principles and Applications	
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	1	
Workload in Hours	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 M0921: Electi	onic Circuits for Medical Applic	ations		
Courses				
Fitle Electronic Circuits for Medical Appli Electronic Circuits for Medical Appli	cations (L1056)	Typ Lecture Recitation Section (sm		CP 3 2
Electronic Circuits for Medical Appli		Practical Course	1	1
Module Responsible Admission Requirements				
	Fundamentals of electrical engineering			
Knowledge	rundamentals of electrical engineering			
_	After taking part successfully, students have r	eached the following learning results		
Professional Competence	5	5 5		
Knowledge	 Students can explain the basic function Students are able to explain the build-u Students can exemplify the communica Students can describe the special featu Students can explain the functions of p Students are able to discuss the potent 	p of an action potential and its propagat ition between neurons and electronic de res of low-noise amplifiers for medical a rostheses, e. g. an artificial hand	tion along an axon vices pplications	
Skills	 Students can calculate the time deper Students can give scenarios for further Students can develop the block diagra Students can define the building blocks 	improvement of low-noise and low-powers of prosthetic systems	er signal acquisition.	
Personal Competence <i>Social Competence</i>	 Students are trained to solve problem professional background. Students are able to recognize their speter students can document their work in a whenever it is necessary 	ecific limitations, so that they can ask fo	r assistance to the right tir	me.
Autonomy	 Students are able to realistically judinecessary. Students can break down their work in Students can handle the complex data Students are able to act in a responsible 	appropriate work packages and schedul structures of bioelectrical experiments v	e their work in a realistic v vithout needing support.	
Workload in Hours	Independent Study Time 124, Study Time in L	ecture 56		
Credit points	6			
Course achievement	Compulsory Bonus Form Yes None Subject theoretical practical work No None Excercises	Description and		
Examination	Written exam			
Examination duration and	90 min			
scale Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Artifici Biomedical Engineering: Specialisation Implan Biomedical Engineering: Specialisation Medica Biomedical Engineering: Specialisation Manag	al Organs and Regenerative Medicine: El ts and Endoprostheses: Elective Compu Il Technology and Control Theory: Comp	lsory ulsory	
	Microelectronics and Microsystems: Specialisa Theoretical Mechanical Engineering: Technica Theoretical Mechanical Engineering: Specialis	l Complementary Course: Elective Comp	oulsory	

Course L0696: Electronic Cire	cuits for Medical Applications
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
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 Cire	ourse L1056: Electronic Circuits for Medical Applications	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
Workload in Hours	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: Electronic Cire	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
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/

Courses				
Title Applied Humanoid Robotics (L1794) Project-/problem-based Learnin	Hrs/wk	CP 6	
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous Knowledge	 Object oriented programming; algorithms and data structures Introduction to control systems Control systems theory and design Mechanics 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence Knowledge	 Students can explain humanoid robots. Students can explain the basic concepts, relationships and methods of forward- and inv Students learn to apply basic control concepts for different tasks in humanoid robotics. 	erse kinematics		
Skills	 Students can implement models for humanoid robotic systems in Matlab and C++, and use these models for robot motio other tasks. They are capable of using models in Matlab for simulation and testing these models if necessary with C++ code on the robot system. They are capable of selecting methods for solving abstract problems, for which no standard methods are available, apply it successfully. 			
Personal Competence <i>Social Competence</i> <i>Autonomy</i>	 Students can develop joint solutions in mixed teams and present these. They can provide appropriate feedback to others, and constructively handle feedback of Students are able to obtain required information from provided literature sources, a lecture. 			
	They can independently define tasks and apply the appropriate means to solve them.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	5-10 pages			
scale				
Assignment for the	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory			
Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compu	sory		
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Com	oulsory		
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective C	ompulsory		

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

Courses				
Title		Тур	Hrs/wk	СР
Medical Imaging Systems (L0819)		Lecture	4	6
Module Responsible	Dr. Michael Grass			
Admission Requirements	None			
Recommended Previous	none			
Knowledge				
Educational Objectives	After taking part successfully, students have reache	ed the following learning results		
Professional Competence				
Knowledge				
	Students can:			
	 Describe the system configuration and comp 	opents of the main clinical imagir	na systems.	
	 Explain how the system components and the 			
	 Explain and apply the physical processes that 			sical equations;
	 Name and describe the physical effects required 			• •
	 Explain how spatial and temporal resolution can be influenced and how to characterize the images generated; 			
	Explain which image reconstruction methods are used to generate images;			
	Describe and explain the main clinical uses of the c	ifferent systems.		
Skills	Students are able to:			
	Explain the physical processes of images and	laccian to the systems the basis	mathematical or physical	aquations require
	 Calculate the parameters of imaging s 	• •		equations require
	 Determine the influence of different sy 			if imaging system
	 Explain the importance of different im 			. indging of seen
	Select a suitable imaging system for an application			
Personal Competence				
Social Competence	none			
	Students can:			
, accitotity				
	Understand which physical effects are used i			
	Decide independently for which clinical issue	a measuring system can be used	I.	
Workload in Hours	Independent Study Time 124, Study Time in Lectur	e 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Medical Techr	ology: Elective Compulsory		
Following Curricula	Biomedical Engineering: Core qualification: Comput	sory		
	Product Development, Materials and Production: Sp	ecialisation Product Development	: Elective Compulsory	
	Product Development, Materials and Production: Sp	ecialisation Production: Elective C	Compulsory	
	Product Development, Materials and Production: Sp			
	Theoretical Mechanical Engineering: Technical Com			
	Theoretical Mechanical Engineering: Specialisation	Bio- and Medical Technology: Elec	tive Compulsory	

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Course L0819: Medical Imagi				
Тур	Lecture			
Hrs/wk	4			
СР	6			
Workload in Hours	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.			

1odule M1335: BIO II				
Courses				
Гitle		Тур	Hrs/wk	СР
Artificial Joint Replacement (L1306		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical	techniques is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
Knowledge	The students can name the different kinds o	f artificial limbs.		
Chille	The students can explain the advantages and disadvantages of different kinds of endoprotheses.			
SKIIIS	The students can explain the advantages an	in disadvantages of different kinds of end	ioprocheses.	
Personal Competence				
Social Competence	The students are able to discuss issues relat	ed to endoprothese with student mates a	and the teachers.	
Autonomy	The students are able to acquire information	on their own. They can also judge the in	formation with respect to	ite credibility
Autonomy	The students are able to acquire information	ron their own. They can also judge the in	normation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time in I	Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering:	Specialisation II. Process Engineering an	d Biotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano and H	Hybrid Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
	Biomedical Engineering: Specialisation Impla	ants and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Medi	cal Technology and Control Theory: Elect	ive Compulsory	
	Biomedical Engineering: Specialisation Mana	agement and Business Administration: Ele	ective Compulsory	
	Orientation Studies: Core qualification: Elect	ive Compulsory		
	Theoretical Mechanical Engineering: Technic	al Complementary Course: Elective Com	pulsory	
	Theoretical Mechanical Engineering: Special	isation Bio- and Medical Technology: Elec	tive Compulsory	

Course L1306: Artificial Joint	Replacement	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	SoSe	
Content	Inhalt (deutsch)	
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes)	
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)	
	3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate)	
	AS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten)	
	ER 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)	
Literature	Literatur:	
	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	

	tics and Naviga	ation in Medicin	e			
Courses						
Title			Тур	Hrs/wk	СР	
Robotics and Navigation in Medicir	e (L0335)		Lecture	2	3	
Robotics and Navigation in Medicir			Project Seminar	2	2	
Robotics and Navigation in Medicir	e (L0336)		Recitation Section (sma	all) 1	1	
Module Responsible	Prof. Alexander Schla	aefer				
Admission Requirements	None					
Recommended Previous						
Knowledge	 principles of m 	nath (algebra, analysis/	calculus)			
	 principles of p 	programming, e.g., in Jav	va or C++			
	 solid R or Matl 	lab skills				
Educational Objectives	After taking part suc	cessfully students have	reached the following learning results			
Professional Competence	, incer taking part suc					
-	The students can e	volain kinematics and t	racking systems in clinical contexts and	illustrate systems and	d their components	
Kilowieuge			pect to collision detection and safety ar	-		
	-	esign and limitations.	peet to conside detection and safety a		its can assess typi	
	systems regarding u	esign and innitations.				
Skills	The students are abl	e to design and evaluat	e navigation systems and robotic systems	for medical application	ıs.	
Personal Competence						
Social Competence	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work.					
	······································					
Autonomy	The students can ref	flect their knowledge a	nd document the results of their work. The	ey can present the res	sults in an appropria	
	manner.					
Workload in Hours	Independent Study T	ime 110, Study Time in	Lecture 70			
Credit points						
Course achievement		Form	Description			
course achievement	Yes 10 %	Written elaboration	·			
	Yes 10 %	Presentation				
Examination	Written exam					
Examination duration and	90 minutes					
scale	o o minaceo					
	Computer Science: S	Specialisation II: Intellige	nce Engineering: Elective Compulsory			
•			Il Technology: Elective Compulsory			
Tonowing curricula	-			active Compulsory		
	International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory					
	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: 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 Engineer					
	Biomedical Engineer Biomedical Engineer	ing: Specialisation Impla	ants and Endoprostheses: Elective Compuls	sory		
	Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri	ing: Specialisation Implaing: Specialisation Medi	ants and Endoprostheses: Elective Compuls cal Technology and Control Theory: Elective	sory e Compulsory		
	Biomedical Engineer Biomedical Engineer Biomedical Engineer Biomedical Engineer	ing: Specialisation Implaing: Specialisation Medi ing: Specialisation Medi	ants and Endoprostheses: Elective Compuls cal Technology and Control Theory: Elective agement and Business Administration: Elec	ory e Compulsory tive Compulsory		
	Biomedical Engineer Biomedical Engineer Biomedical Engineer Biomedical Engineer Product Developmen	ing: Specialisation Impla ing: Specialisation Medi ing: Specialisation Mana it, Materials and Produc	ants and Endoprostheses: Elective Compuls cal Technology and Control Theory: Elective agement and Business Administration: Elec tion: Specialisation Product Development: E	ory e Compulsory tive Compulsory Elective Compulsory		
	Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Product Developmen Product Developmen	ing: Specialisation Impla ing: Specialisation Medi ing: Specialisation Mana it, Materials and Produc it, Materials and Produc	ants and Endoprostheses: Elective Compuls cal Technology and Control Theory: Elective agement and Business Administration: Elec tion: Specialisation Product Development: E tion: Specialisation Production: Elective Con	sory e Compulsory tive Compulsory Elective Compulsory mpulsory		
	Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Product Developmen Product Developmen Product Developmen	ing: Specialisation Impli ing: Specialisation Medi ing: Specialisation Mana it, Materials and Produc it, Materials and Produc it, Materials and Produc	ants and Endoprostheses: Elective Compuls cal Technology and Control Theory: Elective agement and Business Administration: Elec tion: Specialisation Product Development: E	sory e Compulsory tive Compulsory Elective Compulsory mpulsory pulsory		

Түр	Lecture
Hrs/wk	
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	SoSe
Content	- kinematics
	- calibration
	- tracking systems
	- navigation and image guidance
	- motion compensation
	The seminar extends and complements the contents of the lecture with respect to recent research results.
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	rse L0338: Robotics and Navigation in Medicine			
Тур	Project Seminar			
Hrs/wk	2			
СР	2			
Workload in Hours	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	rse L0336: Robotics and Navigation 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	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M1182: Techr	nical Elective Course for TMBMS (according to Subject Specific Regulations)	
Courses		
Title	Typ Hrs/wk	СР
Module Responsible	Prof. Robert Seifried	
Admission Requirements	None	
Recommended Previous	see FSPO	
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	see FSPO	
Autonomy	see FSPO	
Workload in Hours	Depends on choice of courses	
Credit points	6	
Assignment for the	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory	
Following Curricula	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 M1249: Medio	cal Imaging			
Courses				
Title		Тур	Hrs/wk	СР
Medical Imaging (L1694)		Lecture	2	3
Medical Imaging (L1695)		Recitation Section (small)	2	3
Module Responsible				
Admission Requirements		ice and signal processing		
Recommended Previous Knowledge	Basic knowledge in linear algebra, numer	ics, and signal processing		
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence	Firef taking part successionly, stadents in			
	After successful completion of the module, students are able to describe reconstruction methods for different tomographic ima modalities such as computed tomography and magnetic resonance imaging. They know the necessary basics from the fiel signal processing and inverse problems and are familiar with both analytical and iterative image reconstruction methods. students have a deepened knowledge of the imaging operators of computed tomography and magnetic resonance imaging. The students are able to implement reconstruction methods and test them using tomographic measurement data. They			
	visualize the reconstructed images and temporal complexity of imaging algorithm	evaluate the quality of their data and results. ns.	In addition, studer	its can estimate t
Personal Competence				
Social Competence	Students can work on complex problems individual strengths to solve the problem.	both independently and in teams. They can exch	ange ideas with eac	h other and use th
Autonomy	Students are able to independently invest	tigate a complex problem and assess which comp	petencies are require	ed to solve it.
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the	Computer Science: Specialisation II: Intell	igence Engineering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Med			
		cion Computational Methods in Biomedical Imagin	•	
		ialisation Communication and Signal Processing:		
	Theoretical Mechanical Engineering: Spec Theoretical Mechanical Engineering: Tech	cialisation Bio- and Medical Technology: Elective (

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

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

Module M0746: Micro	system	Enginee	ering						
Courses									
Title						Тур		Hrs/wk	СР
Microsystem Engineering (L0680)						Lecture		2	4
Microsystem Engineering (L0682)						Project-/problem-b	ased Learning	2	2
Module Responsible	Dr. rer. nat	t. Thomas K	lusserow						
Admission Requirements	None								
Recommended Previous	Basic cours	ses in physi	ics, mathemati	ics and elec	ctric engineering	l			
Knowledge									
Educational Objectives	After takin	g part succ	essfully, studei	nts have re	ached the follow	ving learning results	5		
Professional Competence									
Knowledge	The studer actuators.	The students know about the most important technologies and materials of MEMS as well as their applications in sensors an actuators.							
Skills	Students are able to analyze and describe the functional behaviour of MEMS components and to evaluate the potential o microsystems.						ate the potential o		
Personal Competence									
Social Competence	Students a	ire able to s	olve specific p	roblems al	one or in a group	o and to present the	e results accord	dingly.	
Autonomy	Students a other fields		acquire particu	ılar knowle	dge using speci	alized literature and	d to integrate	and associate	this knowledge wit
Workload in Hours	Independe	nt Study Tir	me 124. Studv	Time in Le	cture 56				
Credit points									
Course achievement	Compulsory No	Bonus 10 %	Form Presentation		Description				
Examination	Written exa	am							
Examination duration and	2h								
scale									
Assignment for the	Electrical E	Engineering	: Core qualifica	ation: Comp	oulsory				
Following Curricula	Internation	nal Manager	ment and Engir	neering: Sp	ecialisation II. E	lectrical Engineerin	g: Elective Con	npulsory	
	Internation	nal Manager	ment and Engir	neering: Sp	ecialisation II. M	lechatronics: Electiv	e Compulsory		
	Mechanica	l Engineerir	ng and Manage	ement: Spe	cialisation Mech	atronics: Elective C	ompulsory		
	Mechatron	ics: Special	isation System	Design: El	ective Compulso	ory			
			-		ication: Elective				
						Course: Elective Co			
	Theoretica	l Mechanica	al Engineering:	Specialisa	tion Bio- and Me	dical Technology: E	lective Compu	lsory	

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Course L0680: Microsystem E	Engineering						
	Lecture						
Hrs/wk							
CP							
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28						
Lecturer	Dr. rer. nat. Thomas Kusserow						
Language							
Cycle							
Content	Object and goal of MEMS						
	Scaling Rules						
	Lithography						
	Film deposition						
	Structuring and etching						
	Energy conversion and force generation						
	Electromagnetic Actuators						
	Reluctance motors						
	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						
Literature	M. Kasper: Mikrosystementwurf, Springer (2000)						
	M. Madou: Fundamentals of Microfabrication, CRC Press (1997)						

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

Courses								
Title					Тур	Hrs/wk	СР	
ntelligent Systems in Medicine (LO	331)				Lecture	2	3	
ntelligent Systems in Medicine (LO	334)				Project Seminar	2	2	
ntelligent Systems in Medicine (LO	333)				Recitation Section (small)	1	1	
Module Responsible	Prof. Alexa	nder Schla	efer					
Admission Requirements	None							
Recommended Previous Knowledge	prineprine	 principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, Java/C++ and R/Matlab advanced programming skills 						
Educational Objectives	After taking	g part succ	essfully, student	s have reached the follow	ing learning results			
Professional Competence								
Skills	in clinical c in the cont and safety The studer	optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantage in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate method in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to priva and safety requirements. The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can asset the methods based on actual patient data and evaluate the implemented methods.						
Personal Competence								
	The studer	nts discuss	the results of ot	er groups, provide helpfu	I feedback and can incoorpora	ate feedback into	their work.	
					esults of their work. They can			
Workload in Hours	Independe	nt Study Ti	ime 110, Study T	me in Lecture 70				
Credit points	6							
Course achievement	Compulsory Yes Yes	10 % 10 %	Form Presentation Written elabor	Description				
Examination								
Examination duration and	90 minutes	5						
scale	C	<u> </u>						
-				telligence Engineering: El				
Following Curricula				Aedical Technology: Elect	thods in Biomedical Imaging:	Compulsory		
				t Systems and Robotics: I		compaisory		
			-	•	generative Medicine: Elective	Compulsory		
					neses: Elective Compulsory			
		5	5		1 5			
	Biomedical	I Engineeri	ng: Specialisatio	i Medical Technology and	Control Theory: Elective Com	pulsory		
					control Theory: Elective Com ess Administration: Elective Co			
	Biomedical	l Engineeri	ng: Specialisatio	Management and Busine				

Course L0331: Intelligent Sy	stems in Medicine
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	 methods for search, optimization, planning, classification, regression and prediction in a clinical context representation of medical knowledge understanding challenges due to clinical and patient related data and data acquisition The students will work in groups to apply the methods introduced during the lecture using problem based learning.
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 Sy	rrse L0334: Intelligent Systems in Medicine				
Тур	Project Seminar				
Hrs/wk	2				
СР	2				
Workload in Hours	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 Sy	ourse L0333: Intelligent Systems in Medicine				
Тур	Recitation Section (small)				
Hrs/wk	1				
CP	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				

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 M1235: Electrical Power Systems I: Introduction to Electrical Power Systems

Courses									
Title		Тур	Hrs/wk	СР					
-	ction to Electrical Power Systems (L1670)	Lecture	3	4					
Electrical Power Systems I: Introdu	ction to Electrical Power Systems (L1671)	Recitation Section (small)	2	2					
Module Responsible	Prof. Christian Becker								
Admission Requirements	None								
Recommended Previous	Fundamentals of Electrical Engineering								
Knowledge									
Educational Objectives	After taking part successfully, students have reached t	he following learning results							
Professional Competence									
Knowledge	Students are able to give an overview of conventional	and modern electric power systems. T	hey can explain i	n detail and critica					
	evaluate technologies of electric power generation, tra	insmission, storage, and distribution as	well as integrati	on of equipment i					
	electric power systems.								
Skills	With completion of this module the students are al	ble to apply the acquired skills in ap	plications of the	design integrati					
	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	nce The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own we								
	front of others.								
Autonomy	Students can independently tap knowledge of the emp	hasis of the lectures.							
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	90 - 150 minutes								
scale									
Assignment for the	General Engineering Science (German program, 7 sem	ester): Specialisation Electrical Enginee	ering: Elective Co	mpulsory					
Following Curricula	General Engineering Science (German program, 7 sem	ester): Specialisation Green Technologi	ies, Focus Renew	able Energy: Elect					
	Compulsory								
	Data Science: Core qualification: Elective Compulsory								
	Electrical Engineering: Core qualification: Elective Com	pulsory							
	Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory								
	Energy Systems: Specialisation Energy Systems: Election	ve Compulsory							
	General Engineering Science (English program, 7 seme	ester): Specialisation Electrical Engineer	ring: Elective Cor	npulsory					
	Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: Elective Compulsory								
	Computational Science and Engineering: Specialisation	II. Mathematics & Engineering Science	e: Elective Compu	llsory					
	Renewable Energies: Core qualification: Compulsory								
	Theoretical Mechanical Engineering: Technical Comple	mentary Course: Elective Compulsory							
	Theoretical Mechanical Engineering: Specialisation Ene	ray Systems: Elective Compulsory							

Course L1670: Electrical Pow	ver Systems I: Introduction to Electrical Power Systems					
Тур	Lecture					
Hrs/wk						
CP	4					
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42					
Lecturer	Prof. Christian Becker					
Language	DE					
Cycle	WiSe					
Content	 fundamentals and current development trends in electric power engineering tasks and history of electric power systems symmetric three-phase systems fundamentals and modelling of eletric power systems lines transformers synchronous machines induction machines loads and compensation grid structures and substations fundamentals of energy conversion electro-mechanical energy conversion thermodynamics power station technology renewable energy conversion systems steady-state network calculation network modelling load flow calculation (n-1)-criterion symmetric failure calculations, short-circuit power control in networks and power stations 					
	grid protection					
	grid planning power economy fundamentals					
	power economy fundamentals					
Literature	K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013					
	A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017					
	R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008					

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

Courses				
Title		Turn	Hrs/wk	СР
Thermal Engergy Systems (L0023)		Typ Lecture	3	5
Thermal Engergy Systems (L0024)		Recitation Section (large)	1	1
Module Responsible	NN			
Admission Requirements				
Recommended Previous	Technical Thermodynamics I, II, Fluid Dynamics	, Heat Transfer		
Knowledge				
Educational Objectives	After taking part successfully, students have rea	ached the following learning results		
Professional Competence				
Knowledge	Students know the different energy conversion	n stages and the difference between efficier	ncy and annual e	efficiency. They ha
	increased knowledge in heat and mass transfe	r, especially in regard to buildings and mobi	le applications. T	hey are familiar v
	German energy saving code and other technica	al relevant rules. They know to differ different	heating systems	in the domestic a
	industrial area and how to control such heat	ing systems. They are able to model a fu	rnace and to ca	Iculate the transi
	temperatures in a furnace. They have the bas	sic knowledge of emission formations in the	flames of small	burners and how
	conduct the flue gases into the atmosphere. Th	ey are able to model thermodynamic systems	with object orier	nted languages.
Skills	Students are able to calculate the heating dema	and for different heating systems and to choo	se the suitable c	omponents. They
	able to calculate a pipeline network and have t	• •		
	Modelica programs and can transfer research			
	thermal engineering.			
Personal Competence				
	The students are able to discuss in small groups	s and develop an approach.		
	····			
Autonomy	Students are able to define independently tasks	s, to get new knowledge from existing knowle	dge as well as to	find ways to use
	knowledge in practice.			
Workload in Hours	Independent Study Time 124, Study Time in Leo	cture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Bioprocess Engineering: Specialisation A - Gene	ral Bioprocess Engineering: Elective Compuls	ory	
-	Energy and Environmental Engineering: Special		•	
-	Energy Systems: Specialisation Energy Systems			
	Energy Systems: Specialisation Marine Engineer	ring: Elective Compulsory		
	International Management and Engineering: Spo	•	neering: Elective	Compulsory
	Product Development, Materials and Production	•••	-	
	Renewable Energies: Core qualification: Compu			
	Theoretical Mechanical Engineering: Specialisat	•		
	Theoretical Mechanical Engineering: Technical (Complementary Course: Elective Compulsory		

Course L0023: Thermal Engergy Systems	
	Lecture
Hrs/wk	3
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	NN
Language	DE
Cycle	WiSe
Content	1. Introduction
	 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 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 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 Laws and standards 5.1 Buildings 5.2 Industrial plants
Literature	 Schmitz, G.: Klimaanlagen, Skript zur Vorlesung VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 Recknagel, H.; Sprenger, E.; Schrammek, ER.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

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	NN
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Courses				
Title		Тур	Hrs/wk	СР
	nental and Power Train Engineering (L1286)	Lecture	3	5
	nental and Power Train Engineering (L1287)	Recitation Section (small)	1	1
Module Responsible	Dr. Christian Scharfetter			
Admission Requirements	None			
Recommended Previous				
Knowledge				
-	"Gas and Steam Power Plants"			
	"Technical Thermodynamics I & II"			
	"Fluid Mechanics"			
	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	After successful completion of the module the studen	ts must be in a position to:		
	 name and identify the various parts and constr 	uctive groups of steam turbines		
	 describe and explain the key operating conditi 	ons for the application of steam turbines	5	
	classify different construction types and different	entiate among steam turbines according	to size and operation	ating ranges
	describe the thermodynamic processes and th	e constructive and operational repercus	sions resulting fro	om the latter
	calculate thermodynamically a turbine stage a	nd a stage assembly		
	 calculate or estimate and further evaluate sector 	ions of the turbine		
	 outline diagrams describing the operating range 			
	 investigate the constructive aspects and d 	evelop from the thermodynamic requ	uirements the r	equired construct
	characteristics			
	discuss and argue on the operation characteris			
	 evaluate thermodynamically the integration of 	different turbine designs in heat cycles.		
Skills	In the module the students learn the fundamental ap	proaches and methods for the design a	and operational e	valuation of comp
	plant, and gain in particular confidence in seeking op	timisations. They specifically:		
			CHARACTER STOLEN	
	 obtain the ability to analyse the potential of anarratic according and tashnical viewnaints 	various energy sources that can be	utilised thermody	ynamically, from t
	energetic-economic and technical viewpoints	limitations in using various onergy s	ourcos for supp	lying baco load a
	 can evaluate the performance and technical balancing reserve power to the electricity grid 	innitations in using various energy s	ources, for supp	nying base load a
	 on the basis of the impact of power plant 	operation on the integrity of component	ants can describ	e the precaution:
	principles for damage prevention	operation on the integrity of compone		
	 can describe the key requirements for the N 	lanagement and Design of Thermal Po	ower Plants, base	ed on the overrid
	demands imposed by various legislative frame	5 5	,	
Personal Competence				
	In the module the students learn:			
, ,				
	 to work together with others whilst seeking a s 	olution		
	 to assist each other in problem solving 			
	to conduct discussions			
	 to present work results to work respectfully, within the team 			
	 to work respectfully within the team. 			
Autonomy	In the module the students learn the independent we	rking of a complex theme whilst consid	ering various asp	ects. They also lea
	how to combine independent functions in a system.			
	The students become the ability to gain independent	v knowledge and transfer it also to a	problem celuin-	
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	Energy and Environmental Engineering: Specialisatio	n Energy Engineering: Elective Compuls	ory	
Following Curricula	International Management and Engineering: Specialis		-	Compulsory
~	Theoretical Mechanical Engineering: Technical Compl		-	
		nergy Systems: Elective Compulsory		

Тур	Lecture
Hrs/wk	3
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Dr. Christian Scharfetter
Language	DE
Cycle	WiSe
Literature	 Introduction Construction Aspects of a Steam Turbine Energy Conversion in a 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 Convection to thermal and electrical energy networks, interfaces Conventional and regenerative power plant concepts, drive technology Analysis of the global energy supply market Applications in conventional and regenerative power plants Different power plant concepts and their influence on the steam turbine (engine and g turbine power plants with waste heat utilization, geothermal energy, solar thermal energy biomass, biogas, waste incineration). Classic combined heat and power generating profiles Applications in drive technology Operating and maintenance concepts The lecture will be deepened by means of examples, tasks and two excursions Traupel, W.: Thermische Turbomaschinen. Berlin u. a., Springer (TUB HH: Signatur MSI-105) Menny, K.: Strömungsmaschinen: hydraulische und thermische Kraft- und Arbeitsmaschinen. Ausgabe: 5. Wiesbad Teubner, 2006 (TUB HH: Signatur MSI-120) Bohl, W.: Aufbau und Wirkungsweise. Ausgabe 6. Aufl. Würzburg, Vogel, 1999 (TUB HH: Signatur MSI-109)

Course L1287: Steam turbines in energy, environmental and Power Train Engineering	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	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 M1182: Techr	nical Elective Course for TMBMS (according to Subject Specific Regulations)	
Courses		
Title	Typ Hrs/wk	СР
Module Responsible	Prof. Robert Seifried	
Admission Requirements	None	
Recommended Previous	see FSPO	
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	see FSPO	
Autonomy	see FSPO	
Workload in Hours	Depends on choice of courses	
Credit points	6	
Assignment for the	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory	
Following Curricula	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
Energy Meteorology (L0016)		Lecture	1	1
Energy Meteorology (L0017)		Recitation Section (small)	1	1
Collector Technology (L0018)		Lecture	2	2
Solar Power Generation (L0015)		Lecture	2	2
Module Responsible	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended Previous	none			
Knowledge				
Educational Objectives	After taking part successfully, students	have reached the following learning results		
Professional Competence				
Knowledge	With the completion of this module, stu	dents will be able to deal with technical foundation	s and current issues	s and problems in
	field of solar energy and explain and ev	vaulate these critically in consideration of the pric	r curriculum and cu	rrent subject spec
	issues. In particular they can profess	ionally describe the processes within a solar co	ell and explain the	specific features
	application of solar modules. Furthermo	re, they can provide an overview of the collector to	echnology in solar th	nermal systems.
Clille	Students can apply the acquired theor	atical foundations of examplear energy systems	using color radiation	. In this contaxt
SKIIIS		etical foundations of exemplary energy systems	÷	
		e potential and constraints of solar energy system		
		on solar energy systems in consideration of technic		-
		dents can evalute the economic and ecologic conc	litions of these syste	ems. They can sel
	calculation methods within the radiation	h theory for these topics.		
D				
Personal Competence			Adverse de Materia	
Social Competence	Students are able to discuss issues in th	ne thematic fields in the renewable energy sector a	ddressed within the	module.
Autonomy	Students can independently exploit sou	rces and acquire the particular knowledge about t	ne subject area with	respect to empha
	fo the lectures. Furthermore, with the	e assistance of lecturers, they can discrete use	calculation method	ls for analysing a
		ased on this procedure they can concrete asse		
	consequently define the further workflor			-
	Independent Study Time 96, Study Time	e in Lecture 84		
Credit points Course achievement				
Examination				
Examination duration and	3 nours written exam			
scale				1
		Specialisation Energy and Environmental Enginee	ring: Elective Compl	uisory
Following Curricula	Energy Systems: Specialisation Energy S			
		ring: Specialisation II. Renewable Energy: Elective		
		ring: Specialisation II. Energy and Environmental E	ngineering: Elective	Compulsory
	Renewable Energies: Core qualification:	Compulsory		
	Theoretical Mechanical Engineering: Spe	ecialisation Energy Systems: Elective Compulsory		
	Theoretical Mechanical Engineering: Teo	chnical Complementary Course: Elective Compulso	ry	

Course L0016: Energy Meteo	rology
Тур	Lecture
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Volker Matthias, Dr. Beate Geyer
Language	DE
Cycle	SoSe
Content	
Literature	 Helmut Kraus: Die Atmosphäre der Erde Hans Häckel: Meteorologie Grant W. Petty: A First Course in Atmosheric Radiation Martin Kaltschmitt, Wolfgang Streicher, Andreas Wiese: Renewable Energy Alexander Löw, Volker Matthias: Skript Optik Strahlung Fernerkundung

Course L0017: Energy Meteo	ourse L0017: Energy Meteorology	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	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: Collector Tech	nnology
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Agis Papadopoulos
Language	DE
Cycle	SoSe
Content	 Introduction: Energy demand and application of solar energy. Heat transfer in the solar thermal energy: conduction, convection, radiation. Collectors: Types, structure, efficiency, dimensioning, concentrated systems. Energy storage: Requirements, types. Passive solar energy: components and systems. Solar thermal low temperature systems: collector variants, construction, calculation. Solar thermal high temperature systems: Classification of solar power plants construction. Solar air conditioning. Vorlesungsskript.
	 Kaltschmitt, Streicher und Wiese (Hrsg.). Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, 5. Auflage, Springer, 2013. Stieglitz und Heinzel .Thermische Solarenergie: Grundlagen, Technologie, Anwendungen. Springer, 2012. Von Böckh und Wetzel. Wärmeübertragung: Grundlagen und Praxis, Springer, 2011. Baehr und Stephan. Wärme- und Stoffübertragung. Springer, 2009. de Vos. Thermodynamics of solar energy conversion. Wiley-VCH, 2008. Mohr, Svoboda und Unger. Praxis solarthermischer Kraftwerke. Springer, 1999.

Course L0015: Solar Power G	Constition
Hrs/wk	Lecture
CP	
	Independent Study Time 32, Study Time in Lecture 28
	Martin Schlecht, Prof. Alf Mews, Roman Fritsches, Paola Pignatelli
Language	
Cycle	
Content	Photovoltaics:
	1. Introduction
	2. Primary energies and consumption, available solar energy
	3. Physics of the ideal solar cell
	4. Light absorption, PN transition, characteristic sizes of the solar cell, efficiency
	5. Physics of the real solar cell
	6. Charge carrier recombination, characteristic curves, barrier layer recombination, equivalent circuit diagram
	7. Increasing efficiency
	8. Methods for increasing the quantum yield and reducing recombination
	9. Hetero- and tandem structures
	10. Heterojunction, Schottky, electrochemical, MIS and SIS cell, tandem cell
	11. Concentrator cells
	12. Concentrator optics and tracking systems, concentrator cells
	13. Technology and properties: solar cell types, manufacturing, monocrystalline silicon and gallium arsenide, polycrystalline
	silicon and silicon thin film cells, thin film cells on carriers (amorphous silicon, CIS, electrochemical cells)
	14. Modules
	15. Switches
	Concentrating solar power plants:
	1. Introduction
	2. Point focused technologies
	3. Line focused technologies
	4. Design of CSP projects
Literature	A. Götzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik, Teubner Studienskripten, Stuttgart, 1995
	 A. Götzberger: Sonnenenergie: Photovoltaik : Physik und Technologie der Solarzelle, Teubner Stuttgart, 1994
	 HJ. Lewerenz, H. Jungblut: Photovoltaik, Springer, Berlin, Heidelberg, New York, 1995
	 A. Götzberger: Photovoltaic solar energy generation, Springer, Berlin, 2005
	 C. Hu, R. M. White: Solar Cells, Mc Graw Hill, New York, 1983
	 HG. Wagemann: Grundlagen der photovoltaischen Energiewandlung: Solarstrahlung, Halbleitereigenschaften und
	Solarzellenkonzepte, Teubner, Stuttgart, 1994
	 R. J. van Overstraeten, R.P. Mertens: Physics, technology and use of photovoltaics, Adam Hilger Ltd, Bristol and Boston
	1986
	 B. O. Seraphin: Solar energy conversion Topics of applied physics V 01 31, Springer, Berlin, Heidelberg, New York, 1995
	 P. Würfel: Physics of Solar cells, Principles and new concepts, Wiley-VCH, Weinheim 2005
	 U. Rindelhardt: Photovoltaische Stromversorgung, Teubner-Reihe Umwelt, Stuttgart 2001
	 V. Quaschning: Regenerative Energiesysteme, Hanser, München, 2003
	 G. Schmitz: Regenerative Energien, Ringvorlesung TU Hamburg-Harburg 1994/95, Institut f ür Energietechnik

Module M0721: Air Co	onditioning			
Courses				
Title	Тур		Hrs/wk	СР
Air Conditioning (L0594)	Lecture		3	5
Air Conditioning (L0595)	Recitation Section	on (large)	1	1
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning resu	ults		
Professional Competence				
Knowledge	Students know the different kinds of air conditioning systems for buildings an controlled. They are familiar with the change of state of humid air and are abl They are able to calculate the minimum airflow needed for hygienic conditions i the basic flow pattern in rooms and are able to calculate the air velocity in roon principles to calculate an air duct network. They know the different possibil processes into suitable thermodynamic diagrams. They know the criteria for the	le to draw the sta n rooms and can o ns with the help o lities to produce o	te changes ir choose suitab f simple meth cold and are	n a h1+x,x-diagra le filters. They kno nods. They know t
Skills	Students are able to configure air condition systems for buildings and mobile a network and have the ability to perform simple planning tasks, regarding natu research knowledge into practice. They are able to perform scientific work in the	ral heat sources a	and heat sink	
Personal Competence Social Competence	The students are able to discuss in small groups and develop an approach.			
Autonomy	^r Students are able to define independently tasks, to get new knowledge from ex knowledge in practice.	isting knowledge	as well as to	find ways to use tl
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Energy and Environmental Engineering: Specialisation Energy and Environmenta	al Engineering: Ele	ective Compu	lsory
Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory			
	Energy Systems: Specialisation Marine Engineering: Elective Compulsory			
	International Management and Engineering: Specialisation II. Energy and Environ	nmental Engineer	ing: Elective (Compulsory
	International Management and Engineering: Specialisation II. Aviation Systems:	Elective Compulso	ory	
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective	Compulsory		
	Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Con	mpulsory		
	Process Engineering: Specialisation Process Engineering: Elective Compulsory			

Тур	Lecture
Hrs/wk	3
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	
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
	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	 Schmitz, G.: Klimaanlagen, Skript zur Vorlesung VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 Recknagel, H.; Sprenger, E.; Schrammek, ER.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflag Deutscher Industrieverlag, 2013

Course L0595: Air Conditioni	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	NN	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses				
Title		Тур	Hrs/wk	СР
Lagrangian transport in turbulent fl	ows (L2301)	Lecture	2	3
Computational Fluid Dynamics - Ex		Recitation Section (small)	1	1
Computational Fluid Dynamics in Pr	rocess Engineering (L1052)	Lecture	2	2
Module Responsible	Prof. Michael Schlüter			
Admission Requirements	None			
Recommended Previous				
Knowledge	Mathematics I-IV			
	Basic knowledge in Fluid Mechanics			
	 Basic knowledge in chemical thermodynami 	CS		
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge	After successful completion of the module the stud	lents are able to		
	- evaluin the the basic principles of statistical	thermodynamics (encomples, simple su	(stome)	
	 explain the the basic principles of statistical describe the main approaches in classical M 			ious oncomblos
	 describe the main approaches in classical M discuss examples of computer programs in a 		ar Dynamics) in var	ious ensembles
	 evaluate the application of numerical simula 			
	 list the possible start and boundary conditional 			
Skills	The students are able to:			
	 set up computer programs for solving simple 	e problems by Monte Carlo or molecular	dynamics,	
	 solve problems by molecular modeling, 			
	 set up a numerical grid, 			
	 perform a simple numerical simulation with 	OpenFoam,		
	 evaluate the result of a numerical simulation 	n.		
Personal Competence				
-	The students are able to			
	 develop joint solutions in mixed teams and presented on the solution of the solut	present them in front of the other studer	nts,	
	 to collaborate in a team and to reflect their 	own contribution toward it.		
Autonomy	The students are able to:			
			- 1	
	 evaluate their learning progress and to define a sublistic provide a sublimitient of the sublistic provide a subl	• • •	Dasis,	
	 evaluate possible consequences for their pro- 	bression.		
Workload in Hours	Independent Study Time 110, Study Time in Lectur	re 70		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
	30 min			
scale				
-	Bioprocess Engineering: Specialisation A - General		•	
Following Curricula	Bioprocess Engineering: Specialisation B - Industria			
	Chemical and Bioprocess Engineering: Specialisatio			
	Chemical and Bioprocess Engineering: Specialisatio			
	Energy and Environmental Engineering: Specialisa			ulsory
	Theoretical Mechanical Engineering: Technical Con		У	
	Theoretical Mechanical Engineering: Specialisation		1	
	Theoretical Mechanical Engineering: Specialisation		isory	
	Process Engineering: Specialisation Chemical Proce Process Engineering: Specialisation Process Engine			

Course L2301: Lagrangian transport in turbulent flows	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. 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 methods (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
	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. \rightarrow Knowledge, skills
	The students are trained in the personal competence to independently delve into and research a scientific topic. \rightarrow 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. \rightarrow Knowledge, social competence
	Required knowledge:
	Fluid mechanics 1 and 2 advantageous
	Programming knowledge advantageous
Literature	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.; Muňuzuri, A. P.; Pérez-Muňuzuri, 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.
	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. DOI: 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: Computationa	al Fluid Dynamics - Exercises in OpenFoam		
Тур	citation Section (small)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Michael Schlüter		
Language	EN		
Cycle	SoSe		
Content	 generation of numerical grids with a common grid generator selection of models and boundary conditions basic numerical simulation with OpenFoam within the TUHH CIP-Pool 		
Literature	OpenFoam Tutorials (StudIP)		

Course L1052: Computationa	al Fluid Dynamics in Process Engineering		
Тур	Lecture		
Hrs/wk	2		
СР			
Workload in Hours	lependent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Michael Schlüter		
Language	EN		
Cycle	SoSe		
Content	 Introduction into partial differential equations Basic equations Boundary conditions and grids Numerical methods Finite difference method Finite volume method Time discretisation and stability Population balance Multiphase Systems Modeling of Turbulent Flows Exercises: Stability Analysis Exercises: Example on CFD - analytically/numerically 		
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		

Courses					
		-	11	<u></u>	
Title Sustainability Management (L0007)		Typ Lecture	Hrs/wk 2	CP 1	
Hydro Power Use (L0013)		Lecture	1	1	
Wind Turbine Plants (L0011)		Lecture	2	3	
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1	
Module Responsible	Dr. Isabel Höfer				
Admission Requirements	None				
Recommended Previous	Module: Technical Thermodynamics I,				
Knowledge	Module: Technical Thermodynamics II,				
	Module: Fundamentals of Fluid Mechanics				
Educational Objectives	After taking part successfully, students have	e reached the following learning results			
Professional Competence					
Knowledge	By ending this module students can expla	-		•••	
	offshore conditions and can critical comme	nt these aspects in consideration of curre	ent developments. Furthe	ermore, they are a	
	to describe fundamentally the use of water in the implementation of renewable energy		ts reproduce and explair	n the basic proced	
	Through active discussions of various topi	cs within the seminar of the module st	udents improve their ur	aderstanding and	
	application of the theoretical background ar			activitient and	
Skille	Students are able to apply the acquired t	hoppotical foundations on exemplant wat	tor or wind nowor syste	me and ovaluate	
SKIIIS	Students are able to apply the acquired t assess technically the resulting relationship				
	compare critically the special procedure for				
	in principle applied approach in Europe and			colde Europe with	
			icorecteur projector		
Personal Competence					
Social Competence	Students can discuss scientific tasks subjet	-specificly and multidisciplinary within a s	eminar.		
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of t				
	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					
Course achievement	None				
Examination	Written exam				
Examination duration and	2.5 hours written exam + written elaboration (incl. presentation) in sustainability management				
scale					
Assignment for the	Civil Engineering: Specialisation Structural E	Engineering: Elective Compulsory			
Following Curricula	Civil Engineering: Specialisation Geotechnic	al 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. Energy and Environmental Engineering: Elective Compulsory				
	International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory				
	Product Development, Materials and Product		1 3		
	Product Development, Materials and Produc		1		
	Product Development, Materials and Product		mpulsory		
	Renewable Energies: Core qualification: Cor				
	Theoretical Mechanical Engineering: Technic		-		
	Theoretical Mechanical Engineering: Special	IIsation Energy Systems: Elective Compuls			
		enable Decases Franks and the Florid Co			
	Process Engineering: Specialisation Environ Water and Environmental Engineering: Spec	mental Process Engineering: Elective Com	ipulsory		

Course L0007: Sustainability	Management
Тур	Lecture
Hrs/wk	2
СР	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Anne Rödl
Language	DE
Cycle	SoSe
Content	The lecture "Sustainability Management" gives an insight into the different aspects and dimensions of sustainability. First, essential terms and definitions, significant developments of the last years, and legal framework conditions are explained. The various aspects of sustainability are then presented and discussed in detail. The lecture mainly focuses on concepts for the implementation of the topic sustainability in companies:
	 What is "sustainability"? Why is this concept an important topic for companies? What opportunities and business risks are addressed or are associated with it? How can the often mentioned three pillars of sustainability - economy, ecology, and social- be meaningfully integrated into corporate management despite their sometimes contradictory tendencies, and how a corresponding compromise can be found? What concepts or frameworks exist for the implementation of sustainability management in companies? Which sustainability labels exist for products or companies? What do they have in common, and where do they differ? Furthermore, the lecture is intended to provide insights into the concrete implementation of sustainability aspects into business practice. External lecturers from companies will be invited to report on how sustainability is integrated into their daily processes. In the course of an independently carried out group work, the students will analyze and discuss the implementation of sustainability aspects based on short case studies. By studying and comparing best practice examples, the students will learn about corporate decisions' effects and implications. It should become clear which risks or opportunities are associated if sustainability aspects are taken into account in management decisions.
Literature	Die folgenden Bücher bieten einen Überblick: 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		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Stefan Achleitner		
Language	DE		
Cycle	SoSe		
Content	 Introduction, importance of water power in the national and global context Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems Construction of hydroelectric power plants: description of the individual components and their technical system interaction Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc. Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection Hydropower and the Environment Examples from practice 		
Literature	 Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006 		

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

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

Courses					
Title			Тур	Hrs/wk	СР
Energy from the Ocean (L0002)			Lecture	2	2
Fluid Mechanics II (L0001)			Lecture	Z	4
Module Responsible		er			
Admission Requirements					
Recommended Previous	Wärme- und Stoffüb				
Kilowiedge	warme- und storiub	ertragung			
Educational Objectives	After taking part suc	cessfully, students have	e reached the following learning results		
Professional Competence					
Knowledge	The students are ab	e to describe different a	applications of fluid mechanics for the field	d of Renewable Energies.	They are able to u
	the fundamentals of	fluid mechanics for cale	culations of certain engineering problems	in the field of ocean ener	gy. The students a
	able to estimate if a	problem can be solved	with an analytical solution and what kind	d of alternative possibilitie	es are available (e
	self-similarity, empir	ical solutions, numerica	l methods).		
Skills	Students are able to	use the governing equ	ations of Fluid Dynamics for the design of	f technical processes. Esc	ecially they are al
	Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are ab to formulate momentum and mass balances to optimize the hydrodynamics of technical processes. They are able to transform				
		essage into an abstract			
Personal Competence					
Social Competence	The students are able to discuss a given problem in small groups and to develop an approach. They are able to solve a problem within a team, to prepare a poster with the results and to present the poster.				
	within a team, to pre	epare a poster with the	results and to present the poster.		
Autonomy	Students are able to	define independently t	asks for problems related to fluid mechar	nics. They are able to wor	k out the knowled
	that is necessary to	solve the problem by th	emselves on the basis of the existing kno	wledge from the lecture.	
Workload in Hours	Independent Study 1	ime 124, Study Time ir	lecture 56		
Credit points					
Course achievement		Form	Description		
	Yes 10 %	Group discussion			
Examination	Written exam				
Examination duration and	3h				
scale					
Assignment for the	Energy Systems: Co	re qualification: Elective	Compulsory		
Following Curricula	International Manage	ement and Engineering	Specialisation II. Renewable Energy: Elec	tive Compulsory	
	-	: Core qualification: Cor			
		• • •	isation Energy Systems: Elective Compuls	-	
	Theoretical Mechani	cal Engineering: Techni	cal Complementary Course: Elective Comp	oulsory	

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

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

Module M0515: Energ	y Information Systems and Electromobili	ty		
Courses				
Title Electrical Power Systems II: Operation and Information Systems of Electrical Power Grids (L1696) Electro mobility (L1833)		Typ Lecture Lecture	Hrs/wk 3 2	CP 4 2
Module Responsible	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Electrical Engineering			
Educational Objectives	After taking part successfully, students have reached the foll	owing learning results		
-	Students are able to give an overview of the electric power engineering in the field of renewable energies. They can explain 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. 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	The students can participate in specialized and interdisciplination for the second structure of the se	ary discussions, advance	ideas and represent their	r own work results
Autonomy	Students can independently tap knowledge of the emphasis of the lectures.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	45 min			
-	Energy and Environmental Engineering: Specialisation Energ Renewable Energies: Specialisation Wind Energy Systems: El Renewable Energies: Specialisation Solar Energy Systems: El	ective Compulsory ective Compulsory		lsory
	Theoretical Mechanical Engineering: Technical Complementa Theoretical Mechanical Engineering: Specialisation Energy Sy			

urse L1696: Electrical Pow	er Systems II: Operation and Information Systems of Electrical Power Grids
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	 steaedy-state modelling of electric power systems conventional components Flexible AC Transmission Systems (FACTS) and HVDC grid modelling grid operation electric power supply processes grid and power system management grid provision grid control systems information and communication systems for power system management IT architectures of bay-, substation and network control level IT integration (energy market / supply shortfall management / asset management) future trends of process control technology smart grids functions and steady-state computations for power system operation and plannung load-flow calculations sensitivity analysis and power flow control power system optimization short-circuit calculation asymmetric failure calculation symmetric components
	 calculation of asymmetric failures state estimation
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 mobili	ty
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Klaus Bonhoff
Language	DE
Cycle	WiSe
Content	 Introduction and environment Definition of electric vehicles Excursus: Electric vehicles with fuel cell Market uptake of electric cars Political / Regulatory Framework Historical Review Electric vehicle portfolio / application examples Mild hybrids with 48 volt technology Lithium-ion battery incl. Costs, roadmap, production, raw materials Vehicle Integration Energy consumption of electric cars Battery life Charging Infrastructure Electric road transport Electric public transport Battery Safety
Literature	Vorlesungsunterlagen/ lecture material

Marine Engineering (L1569) Lecture	on Section (large)			
Electrical Installation on Ships (L1531) Lecture Electrical Installation on Ships (L1532) Rectation Marine Engineering (L1569) Lecture Module Responsible Prof. Christopher Friedrich Wirz Admission Requirements None Recommended Previous Knowledge Educational Objectives After taking part successfully, students have reached the following learni Professional Competence Knowledge. The students are able to describe the state-of-the-art regarding the wide knowledge. The students are able to describe the state-of-the-art regarding the wide knowledge. They further know how to analyze and optimize the interaction describe complex correlations with the specific technical terms in Ge operating behaviour of consumers, describe special requirements or equipment in isolated networks, as e.g. onboard ships, offshore units, power generation and distribution in isolated grids, wave generator protection, selectivity and operational monitoring. Skills The students are skilled to employ basic and detail knowledge regarding board ships. They are further able to assess, analyse and solve technico plants and to design propulsion systems. The students have the skills to with related disciplines. Students are able to calculate short-circuit curre for ships. Autonomy The widespread scope of gained knowledge enables the students to han confidently. Workload in Hours Independent Study Time 96, Study Time in Lecture 84 Credit points 6 Course achievement None Examination Written exam	on Section (large)	Live (colo		
Electrical Installation on Ships (L1531) Lecture Electrical Installation on Ships (L1532) Rectation Marine Engineering (L1569) Marine Engineering (L1570) Rectation Module Responsible Prof. Christopher Friedrich Wirz Admission Requirements None Recommended Previous Knowledge Educational Objectives After taking part successfully, students have reached the following learni Professional Competence Knowledge The students are able to describe the state-of-the-art regarding the wide knowledge. They further know how to analyze and optimize the interaction describe complex correlations with the specific technical terms in Ge operating behaviour of consumers, describe special requirements or equipment in isolated networks, as e.g. onboard ships, offshore units, power generation and distribution in isolated grids, wave generator protection, selectivity and operational monitoring. Skills The students are skilled to employ basic and detail knowledge regarding bard ships. They are further able to assess, analyse and solve technicol plants and to design propulsion systems. The students have the skills to with related disciplines. Students are able to calculate short-circuit current for ships. Autonomy The widespread scope of gained knowledge enables the students to han confidently. Workload in Hours Knowledge in Mone Examination Written exam	on Section (large)	Hrs/wk	СР	
Marine Engineering (L1570) Lecture Recitation Module Responsible Admission Requirements None Prof. Christopher Friedrich Wirz Admission Requirements Knowledge None Educational Objectives Knowledge After taking part successfully, students have reached the following learni Professional Competence Knowledge Knowledge The students are able to describe the state-of-the-art regarding the wide knowledge. They further know how to analyze and optimize the interactiv describe complex correlations with the specific technical terms in Ge operating behaviour of consumers, describe special requirements or equipment in isolated networks, as e.g. onboard ships, offshore units, power generation and distribution in isolated grids, wave generator protection, selectivity and operational monitoring. Skills The students are skilled to employ basic and detail knowledge regarding board ships. They are further able to assess, analyse and solve technic plants and to design propulsion systems. The students have the skills to with related disciplines. Students are able to calculate short-circuit curre for ships. Personal Competence Social Competence The students are able to communicate and cooperate in a professional industry. Autonomy The widespread scope of gained knowledge enables the students to han confidently. Workload in Hours Independent Study Time 96, Study Time in Lecture 84 Credit points 6 Course achievement None		2	2	
Marine Engineering (L1570) Recitation Module Responsible Prof. Christopher Friedrich Wirz Admission Requirements None Recommended Previous Knowledge Educational Objectives After taking part successfully, students have reached the following learni Professional Competence Knowledge Knowledge The students are able to describe the state-of-the-art regarding the wide knowledge. They further know how to analyze and optimize the interactive describe complex correlations with the specific technical terms in Ge operating behaviour of consumers, describe special requirements or equipment in isolated networks, as e.g. onboard ships, offshore units, power generation and distribution in isolated grids, wave generator protection, selectivity and operational monitoring. Skills The students are skilled to employ basic and detail knowledge regarding board ships. They are further able to assess, analyse and solve technic: plants and to design propulsion systems. The students have the skills to with related disciplines. Students are able to calculate short-circuit curre for ships. Personal Competence The students are able to communicate and cooperate in a professional industry. Autonomy The widespread scope of gained knowledge enables the students to han confidently. Workload in Hours Independent Study Time 96, Study Time in Lecture 84 Credit points 6 Course achievement		1	1	
Module Responsible Prof. Christopher Friedrich Wirz Admission Requirements None Recommended Previous Knowledge After taking part successfully, students have reached the following learni Professional Competence Knowledge After taking part successfully, students have reached the following learni Professional Competence Knowledge The students are able to describe the state-of-the-art regarding the wide knowledge. They further know how to analyze and optimize the interactiv describe complex correlations with the specific technical terms in Ge operating behaviour of consumers, describe special requirements or equipment in isolated networks, as e.g. onboard ships, offshore units, power generation and distribution in isolated grids, wave generator protection, selectivity and operational monitoring. Skills The students are skilled to employ basic and detail knowledge regarding board ships. They are further able to assess, analyse and solve technic plants and to design propulsion systems. The students have the skills to with related disciplines. Students are able to calculate short-circuit curre for ships. Personal Competence The students are able to communicate and cooperate in a professiona industry. Autonomy The widespread scope of gained knowledge enables the students to han confidently. Workload in Hours Independent Study Time 96, Study Time in Lecture 84 Credit points 6 Course achievement <thnone< th=""></thnone<>		2	2	
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Professional Competence Knowledge The students are able to describe the state-of-the-art regarding the wide knowledge. They further know how to analyze and optimize the interaction describe complex correlations with the specific technical terms in Ge operating behaviour of consumers, describe special requirements or equipment in isolated networks, as e.g. onboard ships, offshore units, power generation and distribution in isolated grids, wave generator protection, selectivity and operational monitoring. Skills The students are skilled to employ basic and detail knowledge regarding board ships. They are further able to assess, analyse and solve technical plants and to design propulsion systems. The students have the skills to with related disciplines. Students are able to calculate short-circuit curre for ships. Personal Competence Social Competence Autonomy The widespread scope of gained knowledge enables the students to han confidently. Workload in Hours Independent Study Time 96, Study Time in Lecture 84 Credit points 6 Course achievement None Examination Written exam				
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Personal Competence Social Competence Social Competence The students are able to communicate and cooperate in a professional industry. Autonomy The widespread scope of gained knowledge enables the students to han confidently. Workload in Hours Independent Study Time 96, Study Time in Lecture 84 Credit points 6 Course achievement None Examination Written exam	erman and English. n the design of sup factories and emerge systems on ships, a g reciprocating machir	The students ar oppy networks an ency power supp and name requir nery, their select	re able to name ind to the electr ply systems, expl rements for netw tion and operation	
Social Competence The students are able to communicate and cooperate in a professional industry. Autonomy The widespread scope of gained knowledge enables the students to han confidently. Workload in Hours Independent Study Time 96, Study Time in Lecture 84 Credit points 6 Course achievement None Examination Written exam				
workload in Hours Independent Study Time 96, Study Time in Lecture 84 Credit points 6 Course achievement None Examination Written exam	ıl environment in the	shipbuilding an	d component sup	
Credit points 6 Course achievement None Examination Written exam	dle situations in their	future professio	n independently a	
Course achievement None Examination Written exam	Independent Study Time 96, Study Time in Lecture 84			
Examination Written exam				
Examination duration and 90 minutes plus 20 minutes oral exam				
scale				
Assignment for the Energy Systems: Specialisation Energy Systems: Elective Compulsory				
Following Curricula Energy Systems: Specialisation Energy Systems: Compulsory				
Theoretical Mechanical Engineering: Specialisation Energy Systems: Elec Theoretical Mechanical Engineering: Technical Complementary Course: E	tive Compulses :			

Course L1531: Electrical Inst	allation on Ships
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	 performance in service of electrical consumers. 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. power generation and distribution in isolated networks, shaft generators for ships calculation of short circuits and behaviour of switching devices protective devices, selectivity monitoring electrical Propulsion plants for ships
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

ourse L1532: Electrical Installation on Ships		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	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	

ourse 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	
Workload in Hours	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.

Courses				
Fitle Aircraft Energy Systems (L0735)		Typ Lecture	Hrs/wk 3	CP 4
Aircraft Energy Systems (L0739)		Recitation Section (large)	2	2
	Prof. Frank Thielecke			
Admission Requirements	None			
-	Basic knowledge in:			
Knowledge				
	Mathematics			
	MechanicsThermodynamics			
	Electrical Engineering			
	Hydraulics			
	Control Systems			
Educational Objections				
Educational Objectives Professional Competence	After taking part successfully, students have rea	achea the following learning results		
	Students are able to:			
nutricage				
		n points of hydraulic, electrical and high-lift	systems	
	 Give an overview of the functionality of a Evaluation the paged for high lift systems are 			
	 Explain the need for high-lift systems suc Assess the challenge during the design of 			
	· Absess the chancinge during the design of	supply systems of an anciale		
Skills	Students are able to:			
	 Design hydraulic and electric supply syste Design high-lift systems of aircrafts 	ems of aircrafts		
	 Analyze the thermodynamic behaviour of 	air conditioning systems		
Personal Competence				
Social Competence	Students are able to:			
	Perform system design in groups and pre	sent and discuss results		
Autonomy	Students are able to:			
	Reflect the contents of lectures autonome	busiy		
	Independent Study Time 110, Study Time in Lec	ture 70		
Credit points				
Course achievement				
Examination Examination duration and	165 Minutes			
scale	105 Minutes			
	Energy Systems: Specialisation Energy Systems	: Elective Compulsory		
5	Aircraft Systems Engineering: Core qualification			
-	International Management and Engineering: Spe		pulsory	
	Product Development, Materials and Production	: Specialisation Product Development: Electiv	e Compulsory	
	Product Development, Materials and Production	: Specialisation Production: Elective Compuls	ory	
	Product Development, Materials and Production		ſУ	
	Theoretical Mechanical Engineering: Technical C			
	Theoretical Mechanical Engineering: Specialisat	ion Aircraft Systems Engineering: Elective Co	mpulsory	

Course L0735: Aircraft Energ	jy Systems
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	WiSe
Content	 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) Electric Energy Systems (Generators; constant-speed-drives; DC and AC converters; electrical power distribution; bus systems; monitoring; load analysis) High Lift Systems (Principles; investigation of loads and system actuation power; principles and sizing of actuation and positioning systems; safety requirements and devices) Environmental Control Systems (Thermodynamic analysis; expansion and compression cooling systems; control strategies cabin pressure control systems)
Literature	 Moir, Seabridge: Aircraft Systems Green: Aircraft Hydraulic Systems Torenbek: Synthesis of Subsonic Airplane Design SAE1991: ARP; Air Conditioning Systems for Subsonic Airplanes

ourse L0739: Aircraft Energy Systems		
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	

Courses						
Fitle			1	Гур	Hrs/wk	СР
Aircraft Design I (Design of Transpo	ort Aircraft) (L0820)		L	ecture	3	3
Aircraft Design I (Design of Transpo	ort Aircraft) (L0834)		F	Recitation Section (large)	2	3
Module Responsible	Prof. Volker Gollnick					
Admission Requirements	None					
Recommended Previous	 Dachalar Mag 	h Eng				
Knowledge	Bachelor Mec	•				
	Bachelor Trafi	-				
	Vordiplom Me	÷				
	Module Air Tra	ansport Systems				
Educational Objectives	After taking part suc	cessfully, students ha	we reached the following	learning results		
Professional Competence						
Knowledge						
			ed and civil aircraft desig			
		-	nd contributions of the v			
			meter on the civil aircraft	design		
	4. Introduction of	of the principle design	methods			
Skills	Understanding and a	application of design a	and calculation methods			
	Understanding and application of design and calculation methods					
	Understanding of int	erdisciplinary and inte	egrative interdependenci	es		
Personal Competence						
•	Working in interdisciplinary teams					
	Communication					
Autonomy	Organization of work	flows and -strategies				
Workload in Hours	-	Time 110, Study Time				
Credit points	6	Time 110, Study Time	In Lecture 70			
•	Compulsory Bonus	Form	Description			
Course achievement	No 10 %	Attestation	•	einer Konzeptauslegung für	ein Verkehrsflug	76110
Examination		Accordition	Darenandig		entrenkenblidg	2009
Examination duration and						
scale						
	Aircraft Systems End	ineering: Core qualifi	cation: Compulsory			
Following Curricula	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory					
ronowing curricula	-	•		duct Development: Elective	-	
				duct Development: Elective		
			•	duction: Elective Compulso		
					i y	
		• •		urse: Elective Compulsory Is Engineering: Elective Con		

Тур	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick, Jens Thöben
Language	DE
Cycle	WiSe
Content	Introduction into the aircraft design process
	1. Introduction/process of aircraft design/various aircraft configurations
	2. Requirements and design objectives, main design parameter (u.a. payload-range-diagramme)
	3. Statistical methods in overall aircraft design/data base methods
	4. Cabin design (fuselage sizing, cabin interior, loading systems)
	5. Principles of aerodynamic aircraft design (polar, geometry, 2D/3D aerodynamics)
	6. Wing Design
	7. Tail wings and landing gear
	8. Principles of engine design and integration
	9. Flight performance in cruise
	10. Take off and landing field length
	11. Loads and V-n-diagramme
	12. Operating cost calculation
Literature	J. Roskam: "Airplane Design"
	D.P. Raymer: "Aircraft Design - A Conceptual Approach"
	J.P. Fielding: "Introduction to Aircraft Design"
	Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"

Course L0834: Aircraft Design I (Design of Transport Aircraft)		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Volker Gollnick, Jens Thöben	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0771: Flight	t Physics			
Courses	•			
Title		Tura	Une (usle	СР
Aerodynamics and Flight Mechanic	s I (10727)	Typ Lecture	Hrs/wk	3
Flight Mechanics II (L0730)	ST(L0727)	Lecture	2	2
Flight Mechanics II (L0731)		Recitation Section (large)	1	1
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge				
	Mathematics			
	Mechanics			
	Thermodynamics			
	Aviation			
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 Minutes (WS) + 90 Minutes (SS)			
scale				
Assignment for the	Aircraft Systems Engineering: Core quality	fication: Compulsory		
Following Curricula	International Management and Engineeri	ng: Specialisation II. Aviation Systems: Elective Co	mpulsory	
	Product Development, Materials and Prod	duction: Specialisation Product Development: Elect	ive Compulsory	
	Product Development, Materials and Prod	duction: Specialisation Production: Elective Compu	lsory	
	Product Development, Materials and Prod	duction: Specialisation Materials: Elective Compuls	ory	
	Theoretical Mechanical Engineering: Spe	cialisation Aircraft Systems Engineering: Elective C	Compulsory	
	Theoretical Mechanical Engineering: Tecl	hnical Complementary Course: Elective Compulsor	у	

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

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

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

Module M1182: Techr	nical Elective Course for TMBMS (according to Subject Specific Regulations)	
Courses		
Title	Typ Hrs/wk	СР
Module Responsible	Prof. Robert Seifried	
Admission Requirements	None	
Recommended Previous	see FSPO	
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	see FSPO	
Autonomy	see FSPO	
Workload in Hours	Depends on choice of courses	
Credit points	6	
Assignment for the	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory	
Following Curricula	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	
Systems Engineering (L1547) Systems Engineering (L1548)		Lecture Recitation Section (large)	3 1	4 2	
Module Responsible	Prof Balf God	Recitation Section (arge)	1	L	
Admission Requirements					
Recommended Previous					
Knowledge	Mathematics				
Kilowieuge	Machanics				
	Thermodynamics				
	Electrical Engineering				
	Control Systems				
	Previous knowledge in:				
	Aircraft Cabin Systems				
Educational Objectives	After taking part successfully, students have rea	ched the following learning results			
Professional Competence					
Knowledge	Students are able to:				
	• understand systems engineering process mode	els, methods and tools for the development o	f complex System	ns	
	• describe innovation processes and the need fo	novation 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, inclu 				
	 identify environmental conditions and test proc 				
	 value the methodology of requirements-based 		nents engineering	g (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 devel	opment team and integrate themselves with	their role in the c	overall process	
Autonomy	Students are able to:				
Autonomy	 interact and communicate in a development te 	am which has distributed tasks			
Workload in Hours	Independent Study Time 124, Study Time in Lect	ure 56			
Credit points					
Course achievement					
Examination Examination duration and					
scale	120 Minutes				
Assignment for the	Aircraft Systems Engineering: Core qualification:	Compulsory			
-	International Management and Engineering: Spe		oulsorv		
	International Management and Engineering: Spe		-	ompulsory	
	Mechatronics: Specialisation System Design: Ele				
	Mechatronics: Specialisation Intelligent Systems				
	Product Development, Materials and Production:		lsony		
	Product Development, Materials and Production: Product Development, Materials and Production:				
			5		
	Product Development, Materials and Production:		/		
	Theoretical Mechanical Engineering: Technical C				
	Theoretical Mechanical Engineering: Specialisation	on Anciait Systems Engineering: Elective Con	npulsory		

Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	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 integrati
	of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineeri
	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 a
	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	- Skript zur Vorlesung
	- diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE)
	- Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010
	- NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007
	- Hinsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation luftfahrttechnischer Betriebe. Springer, 2010
	- De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010
	- Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt.Verlag, 2008

Course L1548: Systems Engi	ourse L1548: Systems Engineering	
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	2	
Workload in Hours	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	

Courses					
Title		Тур	Hrs/wk	СР	
Flight Control Systems (L0736) Flight Control Systems (L0740)		Lecture Recitation Section (large)	3 2	4 2	
Module Responsible	Prof. Frank Thielecke				
Admission Requirements	None				
Recommended Previous	basic knowledge of:				
Knowledge					
	 mathematics mechanics 				
	thermo dynamics				
	electronics				
	 fluid technology 				
	control technology				
Educational Objectives	After taking part successfully, students have reacl	hed the following learning results			
Professional Competence		- *			
Knowledge	Students are able to				
	- describe the structure of enimerory flight series				
	 describe the structure of primary flight cont corresponding properties and applications 	troi systems as well as actuation-, avionic-,	nign lift systems	in general along w	
	corresponding properties and applications. explain different configurations and design 	s and their origins			
	explain unrerent configurations and design				
Skills	Students are able to				
	size primary flight control actuation systems				
	 size primary night 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 colutions in mixed teams 				
	 Develop joint solutions in mixed teams 				
Autonomy	Students are able to:				
	 derive requirements and perform appropria 	ate vet simplified design processes for airc	raft systems from	n complex issues a	
	circumstances in a self-reliant manner				
	Independent Study Time 110, Study Time in Lecture	lre 70			
Credit points Course achievement					
Examination					
Examination duration and	Written exam				
scale	105 Minutes				
	Aircraft Systems Engineering: Core qualification: (Compulsory			
Following Curricula	International Management and Engineering: Speci		pulsory		
-	Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory				
	Product Development, Materials and Production: S	Specialisation Production: Elective Compulse	ory		
	Product Development, Materials and Production: S	Specialisation Materials: Elective Compulsor	у		
	Theoretical Mechanical Engineering: Technical Con	mplementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation	n Aircraft Systems Engineering: Elective Co	mpulsory		

Course L0736: Flight Control	Systems		
Тур	Lecture		
Hrs/wk	3		
СР	4		
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	. Frank Thielecke		
Language	DE		
Cycle	SoSe		
Content	 Actuation (Principles of actuators; electro-mechanical actuators; modeling, analysis and sizing of position control systems; hydro-mechanic actuation systems) 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) 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) Fuel Systems (Architectures; aviation fuels; system components; fueling system; tank inerting system; fuel management; trim tank) De- and Anti-Ice Systems: (Atmospheric icing conditions; principles of de- and anti-ice systems) 		
Literature	 Moir, Seabridge: Aircraft Systems Torenbek: Synthesis of Subsonic Airplane Design Curry: Aircraft Landing Gear Design: Principles and Practices 		

Course L0740: Flight Control	urse L0740: Flight Control Systems		
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	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title		Тур	Hrs/wk	СР
	gn of Rotorcraft, special operations aircraft, UAV) (L0844) gn of Rotorcraft, special operations aircraft, UAV) (L0847)	Lecture Recitation Section (large)	3 2	3 3
Module Responsible	Prof. Volker Gollnick			
Admission Requirements	None			
Recommended Previous	Aircraft Design I (Design of Transport Aircraft)			
Knowledge	Air Transportation Systems			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
	e Understanding of various flight systems and its special characteristics (supersonic aircraft, rotorcraft, high performance aircra unmanned air systems)			
	Understanding of pro's and con's and physical character	stics of different air systems		
	Understanding of special mission requirements and its im	pact on systems definition and conc	eptual design	
	Intensified knowledge of performance design on various a	ir systems		
Skills	Understanding and application of design and calculation r Understanding of interdisciplinary and integrative interde			
	mission oriented technical definition of air systems			
	special conceptual calculation methods for special equipment characteristics			
	assessment of different design solutions			
Personal Competence				
Social Competence	Working in teams for focused solutions			
	communication, assertiveness, technical persuasion			
Autonomy	Organisation of worksflows and strategies for solutions			
	structured task analysis and definition of solutions			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
	Aircraft Systems Engineering: Core qualification: Elective	Compulsory		
Following Curricula			oulsory	
-	Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory			
	Product Development, Materials and Production: Specialis			
	Theoretical Mechanical Engineering: Specialisation Aircra	t Systems Engineering: Elective Cor	anulsony	

Course L0844: Aircraft Desig	n II (Conceptual Design of Rotorcraft, special operations aircraft, UAV)
Тур	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick, Dr. Bernd Liebhardt, Jens Thöben
Language	DE/EN
Cycle	SoSe
Content	 Design of supersonic civil aircraft Principles of high performance and special operations aircraft design Principles of Rotorcraft Design Principles of Unmanned Air Systems design, air taxis, electric aircraft
Literature	Gareth Padfield: Helicopter Flight Dynamics, butterworth ltd. Raymond Prouty: Helicopter Performance Stability and Control, Krieger Publ. Klaus Hünecke: Das Kampfflugzeug von Heute, Motorbuch Verlag Jay Gundelach: Designing Unmanned Aircraft Systems - Configurative Approach, AIAA

Course L0847: Aircraft Desig	ourse L0847: Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV)	
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Volker Gollnick, Dr. Bernd Liebhardt, Jens Thöben	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses				
Title		Тур	Hrs/wk	СР
Aircraft Cabin Systems (L1545)		Lecture	3	4
Aircraft Cabin Systems (L1546)		Recitation Section (large)	1	2
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge	Mathematics			
	Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Control Systems			
Educational Objectives	After taking part successfully, students have r	eached the following learning results		
Professional Competence				
Knowledge	Students are able to:			
	describe cabin operations, equipment in the cabin and cabin Systems			
	explain the functional and non-functional re-			
	elucidate the necessity of cabin operating sy			
	 assess the challenges human factors integra 	tion in a cabin environment		
Skills	Students are able to:			
	• design a cabin layout for a given business m	odel of an Airline		
	design cabin systems for safe operations			
	• design emergency systems for safe man-ma	chine interaction		
	• solve comfort needs and entertainment requ	irements in the cabin		
Personal Competence				
	Students are able to:			
social competence	 understand existing system solutions and di 	scuss their ideas with experts		
Autonomy	Students are able to:			
hatohomy	 Reflect the contents of lectures and expert p 	resentations self-dependent		
	hencet the contents of feetales and expert			
	Independent Study Time 124, Study Time in L	ecture 56		
Credit points Course achievement				
Examination	Written exam			
Examination duration and				
scale				
Assignment for the	Electrical Engineering: Specialisation Control	nd Power Systems Engineering: Elective Com	oulsory	
-	Energy Systems: Specialisation Energy System	, , ,		
	Aircraft Systems Engineering: Core qualification			
	International Management and Engineering: S		npulsory	
	Product Development, Materials and Production			
	Product Development, Materials and Production			
	Product Development, Materials and Production		-	
	Theoretical Mechanical Engineering: Specialis	ation Aircraft Systems Engineering: Elective Co	ompulsory	
	Theoretical Mechanical Engineering: Technica	Complementary Course [,] Elective Compulsory		

Course L1545: Aircraft 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 al passenger process chains • RFID Aircraft Parts Marking • Energy sources and energy conversion
Literature	 Skript zur Vorlesung Jenkinson, L.R., Simpkin, P., Rhodes, D.: Civil Jet Aircraft Design. London: Arnold, 1999 Rossow, CC., Wolf, K., Horst, P. (Hrsg.): Handbuch der Luftfahrzeugtechnik. Carl Hanser Verlag, 2014 Moir, I., Seabridge, A.: Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, Wiley 2008 Davies, M.: The standard handbook for aeronautical and astronautical engineers. McGraw-Hill, 2003 Kompendium der Flugmedizin. Verbesserte und ergänzte Neuauflage, Nachdruck April 2006. Fürstenfeldbruck, 2006 Campbell, F.C.: Manufacturing Technology for Aerospace Structural Materials. Elsevier Ltd., 2006

Course L1546: Aircraft Cabin	urse L1546: Aircraft Cabin Systems	
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	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				
Courses		-		
Title Avianics of Safty Critical Systems ()	1640)	Typ Lecture	Hrs/wk	CP
Avionics of Safty Critical Systems (Avionics of Safty Critical Systems (Recitation Se		3 1
Avionics of Safty Critical Systems (Practical Cou		2
Module Responsible				
Admission Requirements				
Recommended Previous				
Knowledge				
J.	Mathematics			
	Electrical Engineering			
	 Informatics 			
Educational Objectives	After taking part successfully, students h	ave reached the following learning re	esults	
Professional Competence				
Knowledge	Students can:			
	• describe the most important princi	ples and components of safety-critic	al avionics	
	denote processes and standards or			
	 depict the principles of Integrated 	Modular Avionics (IMA)		
	 can compare hardware and bus sy 	stems used in avionics		
	 assess the difficulties of developing 	g a safety-critical avionics system co	rrectly	
Skills	Students can			
	 operate real-time hardware and sit 	nulations		
	 program A653 applications 			
	 plan avionics architectures up to a 	certain extend		
	 create test scripts and assess test 			
Personal Competence				
Social Competence	Students can:			
	 isintly develop colutions in inhome 			
	 jointly develop solutions in inhomo axchange information formally with 			
	 exchange information formally with present development results in a contract of the second seco			
	 present development results in a c 	onvenient way		
Autonomy	Students can:			
Autonomy				
	 understand the requirements for a 	•		
	 autonomously derive concepts for 	systems based on safety-critical avid	onics	
Maddaadia	Independent Study Time 124 Study Time	in Lastura EG		
	Independent Study Time 124, Study Time			
Credit points Course achievement	6 Compulsory Bonus Form	Description		
course achievement	Yes None Subject theoret			
	practical work			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Con	trol and Power Systems Engineering	: Elective Compulsory	
-	Aircraft Systems Engineering: Core qualif		, ,	
3 • • • • • •	Aircraft Systems Engineering: Specialisat		ulsory	
	Aircraft Systems Engineering: Specialisat			
	Theoretical Mechanical Engineering: Tech			
	Theoretical Mechanical Engineering: Spec	ialisation Aircraft Systems Engineeri	ing: Elective Compulsory	

Course L1640: Avionics of Sa	afty Critical Systems
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	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
	 History and Flight Control Concepts and Redundancy Digital Computers Interfaces and Signals Busses Networks Aircraft Cockpit Software Development Model-based Development Integrated Modular Avionics I Integrated Modular Avionics II
Literature	 Moir, I.; Seabridge, A. & Jukes, M., Civil Avionics Systems Civil Avionics Systems, John Wiley & Sons, Ltd, 2013 Spitzer, C. R. Spitzer, Digital Avionics Handbook, CRC Press, 2007 FAA, Advanced Avionics Handbook U.S. Department of Transportation Federal Aviation Administration, 2009 Moir, I. & Seabridge, A. Aircraft Systems, Wiley, 2008, 3

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 Sa	rse L1652: Avionics of Safty Critical Systems		
Тур	Practical Course		
Hrs/wk	1		
CP	2		
Workload in Hours	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				
Title		Тур	Hrs/wk	СР
	nology in cabin electronics and avionics (L1557)	Lecture	2	2
	nology in cabin electronics and avionics (L1558)	Recitation Section (small)	1	1
Model-Based Systems Engineering (MBSE) with SysML/UML (L1551) Project-/problem-based Learning 3 3			3	
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge	Mathematics			
	Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Control Systems			
	Previous knowledge in:			
	Systems Engineering			
	- Systems Engineering			
Educational Objectives	After taking part successfully, students have reached t	ne following learning results		
Professional Competence				
Knowledge	Students are able to:			
	 describe the structure and operation of computer arc 	hitectures		
	• explain the structure and operation of digital commu	nication Networks		
	• explain architectures of cabin electronics, integrated	modular avionics (IMA) and Aircraft Data	Communicatio	on Network (ADCN)
	$\boldsymbol{\cdot}$ understand the approach of Model-Based Systems	Engineering (MBSE) in the design of ha	rdware and s	oftware-based cal
	systems			
Skills	Students are able to:			
Skiis	understand, operate and maintain a Minicomputer			
	 build up a network communication and communicate 	with other network participants		
	 connect a minicomputer with a cabin management s 		a AFDX®-Ne	twork
	model system functions by means of formal language			
	execute software code on a minicomputer			
Personal Competence				
Social Competence	Students are able to:			
	 elaborate partial results and merge with others to for 	m a complete solution		
Autonomv	Students are able to:			
,	 organize and schedule their practical tasks 			
	Independent Study Time 96, Study Time in Lecture 84			
Credit points Course achievement				
Examination duration and	Written exam			
scale				
Assignment for the	Aircraft Systems Engineering: Specialisation Aircraft Sy	stems: Elective Compulsory		
5	Aircraft Systems Engineering: Core qualification: Electi			
J	International Management and Engineering: Specialisa		sory	
	Product Development, Materials and Production: Specia		-	
	Product Development, Materials and Production: Specia	•		
	Product Development, Materials and Production: Specia			
	Theoretical Mechanical Engineering: Technical Comple			
	Theoretical Mechanical Engineering: Specialisation Airc			

Course L1557: Computer and	d communication technology in cabin electronics and avionics
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	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 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

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 communicat technology in electronic systems in the cabin and in aircraft. For the system engineer the strong interaction of softwar 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 curre principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electron 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 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
	Peripherie. Books on Demand; 1. Auflage, 2003
	- Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherh
	Books on Demand; 1. Auflage, 2004
	- Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern u
	Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006

Тур	Project-/problem-based Learning	
Hrs/wk	3	
CP	3	
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
	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	 Skript zur Vorlesung Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008 Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011 	

Module M1738: Selected Topics of Aeronautical Systems Engineering (Alternative B: 12 LP)

Courses				
Courses				
Title	Typ			CP
Advanced Training Course SE-ZERT		em-based Learning 2 3		3 3
Airline Operations (L1310)	Lecture	2		
Fatigue & Damage Tolerance (L031 Flight Guidance (L0848)		2		3 2
5	Lecture Regitation So			
Flight Guidance (L0854)	Recitation Se	ction (large) 1 3		1 3
Airport Operations (L1276)	Lecture	2		3
Airport Planning (L1275)	Lecture			1
Airport Planning (L1469)	Recitation Se			3
Lightweight Design Practical Course		em-based Learning 3 2		3
Aviation Security (L1549)	Lecture			1
Aviation Security (L1550)	Recitation Se	Cuon (smail) I		3
Aviation and Environment (L2376)	Lecture	2		3
Mechanisms, Systems and Process				
Mission Management (L2374)	Lecture	2		2
Mission Management (L2375)	Recitation Se			1
Turbo Jet Engines (L0908)	Lecture	2		3
Structural Mechanics of Fibre Reinf		2		3
Structural Mechanics of Fibre Reinf				1
System Simulation (L1820)	Lecture	2		2
System Simulation (L1821)	Recitation Se			2
Materials Testing (L0949)	Lecture	2		2
Reliability in Engineering Dynamics		2		2
Reliability in Engineering Dynamics				2
Reliability of Aircraft Systems (L074	19) Lecture	2		3
Module Responsible				
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge	Mathematics			
	Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Hydraulics			
	Control Systems			
Educational Objectives	After taking part successfully, students have reached the following learning re	culte		
Professional Competence	riter taking part successiony, statents have reached the following learning re	.50113		
Knowledge	 Students are able to find their way through selected special areas withit 	n systems engineering	, air transporta	ation system a
	material science			-
	 Students are able to explain basic models and procedures in selected s 	necial areas		
		pecial alcus.		
	 Students are able to interrelate scientific and technical knowledge. 			
Skills	Students are able to apply basic methods in selected areas of engineering.			
Personal Competence				
Social Competence				
Autonomy	Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses			
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the	Aircraft Systems Engineering: Core qualification: Elective Compulsory			
3				

Course L2739: Advanced Training Course SE-ZERT		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	120 min	
scale		
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content		
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der	
	deutschen Übersetzung), ISBN 978-3-9818805-0-2.	
	ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System Life Cycle Processes).	

Course L1310: Airline Operations			
Тур	Lecture		
Hrs/wk	3		
СР	3		
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42		
Examination Form	Klausur		
Examination duration and	90 min		
scale			
Lecturer	Prof. Volker Gollnick, Dr. Karl Echtermeyer		
Language	DE		
Cycle	SoSe		
Content	 Introdution and overview Airline business models Interdependencies in flight planning (network management, slot management, netzwork structures, aircraft circulation) Operative flight preparation (weight & balance, payload/range, etc.) fleet policy Aircraft assessment and fleet planning Airline organisation Aircraft maintenance, repair and overhaul 		
Literature	Volker Gollnick, Dieter Schmitt: The Air Transport System, Springer Berlin Heidelberg New York, 2014 Paul Clark: "Buying the Big Jets", Ashgate 2008 Mike Hirst: The Air Transport System, AIAA, 2008		

Course L0310: Fatigue & Dar	Course L0310: Fatigue & Damage Tolerance		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Mündliche Prüfung		
Examination duration and	45 min		
scale			
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 L0848: Flight Guidan	ce
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	60 min
scale	
	Prof. Volker Gollnick
Language	
Cycle	
Content	Introduction and motivation Flight guidance principles (airspace structures, organization of air navigation services, etc.)
	Cockpit systems and Avionics (cockpit design, cockpit equipment, displays, computers and bus systems)
	Principles of flight measurement techniques (Measurement of position (geometric methods, distance measurement, direction
	measurement) Determination of the aircraft attitude (magnetic field- and inertial sensors) Measurement of speed
	Principles of Navigation
	Radio navigation
	Satellite navigation
	Airspace surveillance (radar systems)
	Commuication systems
	Integrated Navigation and Guidance Systems
Literature	Rudolf Brockhaus, Robert Luckner, Wolfgang Alles: "Flugregelung", Springer Berlin Heidelberg New York, 2011
	Holger Flühr: "Avionik und Flugsicherungssysteme", Springer Berlin Heidelberg New York, 2013
	Volker Gollnick, Dieter Schmitt "Air Transport Systems", Springer Berlin Heidelberg New York, 2016
	R.P.G. Collinson "Introduction to Avionics", Springer Berlin Heidelberg New York 2003

Course L0854: Flight Guidance	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1276: Airport Opera	Course L1276: Airport Operations	
Тур	Lecture	
Hrs/wk	3	
СР	3	
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Examination Form	Klausur	
Examination duration and	90 min	
scale		
Lecturer	Prof. Volker Gollnick, Peter Willems (geb. Bießlich)	
Language	DE	
Cycle	WiSe	
Content	FA-F Flight Operations Flight Operations - Production Infrastructures Operations Planning Master plan Airport capacity Ground	
	handling Terminal operations	
Literature	Richard de Neufville, Amedeo Odoni: Airport Systems, McGraw Hill, 2003	

Course L1275: Airport Planning	
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick, Dr. Ulrich Häp
Language	DE
Cycle	WiSe
Content	 Introduction, definitions, overviewg Runway systems Air space strucutres around airports Airfield lightings, marking and information Airfield and terminal configuration
Literature	N. Ashford, Martin Stanton, Clifton Moore: Airport Operations, John Wiley & Sons, 1991 Richard de Neufville, Amedeo Odoni: Airport Systems, Aviation Week Books, MacGraw Hill, 2003

Course L1469: Airport Planning	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick, Dr. Ulrich Häp
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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

Course L1549: Aviation Security	
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
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 ai transport system. Risk management for the entire system can only be successful in an integrated approach, considering mar 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	- Skript zur Vorlesung - Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011 - Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

Course L1550: Aviation Security	
Тур	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	90 Minuten
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	- Skript zur Vorlesung
	- Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011
	- Glemana, E.M., Nothe B.N. (misg.): Handbuch Luitsicherheit. Universitätsverlag TU Bernin, 2011
	- Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

	Environment
	Lecture
Hrs/wk	
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	SoSe
Content	The lecture provides the necessary basics and methods for understanding the interactions between air traffic and the environme
	both in terms of the effects of weather / climate on flying and with regard to the effects of air traffic on pollutant emissions, noi
	and climate.
	The following topics are covered:
	Atmospheric physics / chemistry
	 Structure and statics
	• Dynamics (water cycle, formation of weather events, high and low pressure areas, wind, gusts and turbulence)
	 Cloud physics (thermodynamics, contrails)
	 Radiation physics (energy balance, greenhouse effect)
	• Photochemistry (ozone chemistry)
	Impact of weather on flying
	 Atmospheric influences on flight performance
	• Flight planning
	• Disturbances due to weather, e.g. thunderstorms, winter weather (icing), clear air turbulence, visibility
	• Effects of climate change and adaptation
	Effects of air traffic on the environment and climate
	Aviation pollutant emissions
	Effect of emissions on concentrations in the atmosphere
	 Climate metrics / models and background scenarios Emissions inventories
	Mitigation measures A Technological measures, e.g. climate optimized aircraft design
	 Technological measures, e.g. climate-optimized aircraft design Alternative fuels
	 Operational measures, e.g. climate-optimized flight planning
	 Operational measures, e.g. cumate-optimized light planning Environmental policy measures, e.g. EU-ETS, CORSIA
	 Potentials and comparison, concept of eco-efficiency
	Local environmental impacts
	 Local air quality (particulate matter, other emissions near the ground)
	 Noise (noise sources, noise metrics, noise impact, measurement, certification, psychoacoustics, noise mitigation)
	• Health effects
	Aspects of sustainability
	 Other aspects, including life cycle emissions, disposal/recycling
	 Relation to global goals, e.g. United Nations goals for sustainable development, Paris climate agreement
Literature	
	Ruijgrok, G.: Elements of Aircraft Pollution, Delft University Press, 2005 Friedrich B., Beis, S.: Emissions of Air Pollutants, Engineer 2004
	Friedrich, R., Reis, S.: Emissions of Air Pollutants, Springer 2004 Janie, M.: The Sustainability of Air Transportation, Ashgata, 2007
	Janic, M.: The Sustainability of Air Transportation, Ashgate, 2007 Schumann, H. (ed.): Atmospheric Division Packaround, Mathada, Transfe, Springer, Barlin, Heidelberg, 2012
	Schumann, U. (ed.): Atmospheric Physics: Background - Methods - Trends, Springer, Berlin, Heidelberg, 2012 Schuldeney, V. Gurie, M. Fundementels of Methodsherg, Springer, 2021
	Spiridonov, V., Curic, M.: Fundamentals of Meteorology, Springer, 2021
	Kaltschmitt, M., Neuling, U.: Biokerosene - Status and Prospects, Springer, 2018
	Roedel, W., Wagner, T.: Physik unserer Umwelt: Die Atmosphäre, Springer, 2017
	W. Bräunling: Flugzeugtriebwerke. Springer-Verlag Berlin, Deutschland, 2009
	G. Brüning, X. Hafer, G. Sachs: Flugleistungen, Springer, 1993

Course L0950: Mechanisms,	Systems and Processes of 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	90 Minuten
scale	
Lecturer	Dr. Jan Oke Peters
Language	DE
Cycle	SoSe
	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 static 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	 E. Macherauch: Praktikum in Werkstoffkunde, Vieweg G. E. Dieter: Mechanical Metallurgy, McGraw-Hill R. Bürgel: Lehr- und Übungsbuch Festigkeitslehre, Vieweg R. Bürgel: Werkstoffe sícher beurteilen und richtig einsetzen, Vieweg

Course L2374: Mission Management	
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	SoSe
Content	
Literature	Brockhaus, Alles, Luckner: Flugregelung, Springer Verlag, 2011
	R.P.G Collinson: Introduction to Avionics Systems, Springer Verlag, 2011

Course L2375: Mission Mana	Course L2375: Mission Management	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Examination Form	Klausur	
Examination duration and	60 min	
scale		
Lecturer	Prof. Volker Gollnick	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0908: Turbo Jet Engines	
	Lecture
Hrs/wk	
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	
Examination duration and	45 min
scale	
Lecturer	Dr. Burkhard Andrich
Language	DE
Cycle	WiSe
Content	 Cycle of the gas turbine Thermodynamics of gas turbine components Wing-, grid- and stage-sizing Operating characteristics of gas turbine components Sizing criteria's for jet engines Development trends of gas turbines and jet engines Maintenance of jet engines
Literature	 Bräunling: Flugzeugtriebwerke Engmann: Technologie des Fliegens Kerrebrock: Aircraft Engines and Gas Turbines

	chanics of Fibre Reinforced Composites
Hrs/wk	
СР	
	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
	Prof. Benedikt Kriegesmann
Language	
Cycle	
Content	Classical laminate theory
	Rules of mixture
	Failure mechanisms and criteria of composites
	Boundary value problems of isotropic and anisotropic shells
	Stability of composite structures
	Optimization of laminated composites
	Modelling composites in FEM
	Numerical multiscale analysis of textile composites
	Progressive failure analysis
Literature	 Schürmann, H., "Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. Wiedemann, J., "Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage. Reddy, J.N., "Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition. Jones, R.M., "Mechanics of Composite Materials", Scripta Book Co., Washington, current edition. Timoshenko, S.P., Gere, J.M., "Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition. Turvey, G.J., Marshall, I.H., "Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition. Herakovich, C.T., "Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition. Mittelstedt, C., Becker, W., "Strukturmechanik ebener Laminate", aktuelle Auflage.

Course L1515: Structural Mechanics of Fibre Reinforced Composites	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
	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	 Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7 M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.

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

Course L0949: Materials Tes	ting
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	90 Minuten
scale	
Lecturer	Dr. Jan Oke Peters
Language	
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
Examination Form	Klausur
Examination duration and	90 min.
scale	
Lecturer	NN
Language	EN
Cycle	SoSe
Content	Method for calculation and testing of reliability of dynamic machine systems
	 Modeling System identification Simulation Processing of measurement data Damage accumulation Test planning and execution
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
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	NN
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0749: Reliability of	Aircraft Systems
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
Language	DE
Cycle	WiSe
Content	 Functions of reliability and safety (regulations, certification requirements) Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment) Reliability analysis of electrical and mechanical systems
Literature	 CS 25.1309 SAE ARP 4754 SAE ARP 4761

Module M1744: Selected Topics of Aeronautical Systems Engineering (Alternative A: 6 LP)

		-		
Courses				
Title		Тур	Hrs/wk	СР
Advanced Training Course SE-ZERT	T (L2739)	Project-/problem-based Learning	2	3
Airline Operations (L1310)		Lecture	3	3
Fatigue & Damage Tolerance (L03	10)	Lecture	2	3
Flight Guidance (L0848)		Lecture	2	2
Flight Guidance (L0854)		Recitation Section (large)	1	1
Airport Operations (L1276)		Lecture	3	3
Airport Planning (L1275)		Lecture	2	2
Airport Planning (L1469)		Recitation Section (small)	1	1
Lightweight Design Practical Cours	ie (L1258)	Project-/problem-based Learning	3	3
Aviation Security (L1549)		Lecture	2	2
Aviation Security (L1550)		Recitation Section (small)	1	1
Aviation and Environment (L2376)	en al Mahariala Tashirar (LOOFO)	Lecture	3	3
Mechanisms, Systems and Process	es of Materials Testing (L0950)	Lecture	2	2
Mission Management (L2374)		Lecture	2	2
Mission Management (L2375)		Recitation Section (small)	1	1
Turbo Jet Engines (L0908)	forced Compositor (11514)	Lecture	2 2	3 3
Structural Mechanics of Fibre Reinf Structural Mechanics of Fibre Reinf		Lecture Recitation Section (large)	2	1
System Simulation (L1820)	Nicea composites (LISIS)	Lecture	2	2
System Simulation (L1820)		Recitation Section (large)	1	2
Materials Testing (L0949)		Lecture	2	2
Reliability in Engineering Dynamics	s (10176)	Lecture	2	2
Reliability in Engineering Dynamics		Recitation Section (small)	1	2
Reliability of Aircraft Systems (L07-		Lecture	2	3
Module Responsible		Lecture	2	5
Admission Requirements				
Recommended Previous				
Knowledge	Mathematics			
	Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Hydraulics			
	Control Systems			
	• Control Systems			
Educational Objectives	After taking part successfully, students have reached the for	ollowing learning results		
Professional Competence				
Knowledge				
	Students are able to find their way through selected	special areas within systems enginee	ring, air trans	sportation system ar
	material science			
	Students are able to explain basic models and proce	edures in selected special areas.		
	Students are able to interrelate scientific and technic	cal knowledge.		
<i></i>				
Skills	Students are able to apply basic methods in selected areas	s of engineering.		
Personal Competence				
Social Competence				
	Students can chose independently, in which fields they war	nt to deepen their knowledge and skill	ls through the	e election of courses
Workload in Hours	Depends on choice of courses			
	-			
Credit points				
Assignment for the	Aircraft Systems Engineering: Core qualification: Elective C			
Assignment for the		Systems Engineering: Elective Compu	ulsory	

Course L2739: Advanced Tra	ining Course SE-ZERT
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	120 min
scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der deutschen Übersetzung), ISBN 978-3-9818805-0-2.
	ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System Life Cycle Processes).

Course L1310: Airline Operat	tions
Тур	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Volker Gollnick, Dr. Karl Echtermeyer
Language	DE
Cycle	SoSe
Content	 Introdution and overview Airline business models Interdependencies in flight planning (network management, slot management, netzwork structures, aircraft circulation) Operative flight preparation (weight & balance, payload/range, etc.) fleet policy Aircraft assessment and fleet planning Airline organisation Aircraft maintenance, repair and overhaul
Literature	Volker Gollnick, Dieter Schmitt: The Air Transport System, Springer Berlin Heidelberg New York, 2014 Paul Clark: "Buying the Big Jets", Ashgate 2008 Mike Hirst: The Air Transport System, AIAA, 2008

Course L0310: Fatigue & Damage Tolerance	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	45 min
scale	
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 L0848: Flight Guidance	
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	60 min
scale	
	Prof. Volker Gollnick
Language	
Cycle	
Content	Introduction and motivation Flight guidance principles (airspace structures, organization of air navigation services, etc.)
	Cockpit systems and Avionics (cockpit design, cockpit equipment, displays, computers and bus systems)
	Principles of flight measurement techniques (Measurement of position (geometric methods, distance measurement, direction
	measurement) Determination of the aircraft attitude (magnetic field- and inertial sensors) Measurement of speed
	Principles of Navigation
	Radio navigation
	Satellite navigation
	Airspace surveillance (radar systems)
	Commuication systems
	Integrated Navigation and Guidance Systems
Literature	Rudolf Brockhaus, Robert Luckner, Wolfgang Alles: "Flugregelung", Springer Berlin Heidelberg New York, 2011
	Holger Flühr: "Avionik und Flugsicherungssysteme", Springer Berlin Heidelberg New York, 2013
	Volker Gollnick, Dieter Schmitt "Air Transport Systems", Springer Berlin Heidelberg New York, 2016
	R.P.G. Collinson "Introduction to Avionics", Springer Berlin Heidelberg New York 2003

Course L0854: Flight Guidance	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1276: Airport Operations	
Тур	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Volker Gollnick, Peter Willems (geb. Bießlich)
Language	DE
Cycle	WiSe
Content	FA-F Flight Operations Flight Operations - Production Infrastructures Operations Planning Master plan Airport capacity Ground
	handling Terminal operations
Literature	Richard de Neufville, Amedeo Odoni: Airport Systems, McGraw Hill, 2003

Course L1275: Airport Plann	ing
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick, Dr. Ulrich Häp
Language	DE
Cycle	WiSe
Content	 Introduction, definitions, overviewg Runway systems Air space strucutres around airports Airfield lightings, marking and information Airfield and terminal configuration
Literature	N. Ashford, Martin Stanton, Clifton Moore: Airport Operations, John Wiley & Sons, 1991 Richard de Neufville, Amedeo Odoni: Airport Systems, Aviation Week Books, MacGraw Hill, 2003

Course L1469: Airport Planning	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick, Dr. Ulrich Häp
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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

Course L1549: Aviation Security	
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	90 Minuten
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	- Skript zur Vorlesung - Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011 - Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

Course L1550: Aviation Security	
Typ Recitation Section (small)	
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	90 Minuten
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	- Skript zur Vorlesung
	- Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011
	- olemana, E.M., Notre B.N. (msg.). Handbuch Luitsicherheit. Universitätsverlag TU bernin, 2011
	- Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

_	Leskus
	Lecture
Hrs/wk	
СР	3
	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	SoSe
Content	The lecture provides the necessary basics and methods for understanding the interactions between air traffic and the environme
	both in terms of the effects of weather / climate on flying and with regard to the effects of air traffic on pollutant emissions, noi
	and climate.
	The following topics are covered:
	The following topics are covered.
	Atmospheric physics / chemistry
	Structure and statics
	 Dynamics (water cycle, formation of weather events, high and low pressure areas, wind, gusts and turbulence)
	 Cloud physics (thermodynamics, contrails)
	 Radiation physics (energy balance, greenhouse effect)
	• Photochemistry (ozone chemistry)
	Impact of weather on flying
	 Atmospheric influences on flight performance
	• Flight planning
	• Disturbances due to weather, e.g. thunderstorms, winter weather (icing), clear air turbulence, visibility
	Effects of climate change and adaptation
	Effects of air traffic on the environment and climate
	Aviation pollutant emissions
	Effect of emissions on concentrations in the atmosphere
	 Climate metrics / models and background scenarios Emissions inventories
	Mitigation measures
	 Technological measures, e.g. climate-optimized aircraft design Alternative fuels
	 Operational measures, e.g. climate-optimized flight planning
	 Environmental policy measures, e.g. EU-ETS, CORSIA
	 Potentials and comparison, concept of eco-efficiency
	Local environmental impacts
	 Local air quality (particulate matter, other emissions near the ground)
	 Noise (noise sources, noise metrics, noise impact, measurement, certification, psychoacoustics, noise mitigation)
	 Health effects
	Aspects of sustainability
	 Other aspects, including life cycle emissions, disposal/recycling
	 Relation to global goals, e.g. United Nations goals for sustainable development, Paris climate agreement
Literature	
	Ruijgrok, G.: Elements of Aircraft Pollution, Delft University Press, 2005 Friedrich D. Beis, S.: Emissions of Air Pollutants, Engineer 2004
	Friedrich, R., Reis, S.: Emissions of Air Pollutants, Springer 2004
	Janic, M.: The Sustainability of Air Transportation, Ashgate, 2007 Schwarzen, H. (cd.): Attracedure: Device: Realized Methods, Tracedo, Cariares, Barlin, Heidelbarg, 2012
	Schumann, U. (ed.): Atmospheric Physics: Background - Methods - Trends, Springer, Berlin, Heidelberg, 2012
	Spiridonov, V., Curic, M.: Fundamentals of Meteorology, Springer, 2021
	Kaltschmitt, M., Neuling, U.: Biokerosene - Status and Prospects, Springer, 2018
	Roedel, W., Wagner, T.: Physik unserer Umwelt: Die Atmosphäre, Springer, 2017
	W. Bräunling: Flugzeugtriebwerke. Springer-Verlag Berlin, Deutschland, 2009
	G. Brüning, X. Hafer, G. Sachs: Flugleistungen, Springer, 1993

Course L0950: Mechanisms,	Systems and Processes of 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	90 Minuten
scale	
Lecturer	Dr. Jan Oke Peters
Language	DE
Cycle	SoSe
	 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	 E. Macherauch: Praktikum in Werkstoffkunde, Vieweg G. E. Dieter: Mechanical Metallurgy, McGraw-Hill R. Bürgel: Lehr- und Übungsbuch Festigkeitslehre, Vieweg R. Bürgel: Werkstoffe sícher beurteilen und richtig einsetzen, Vieweg

Course L2374: Mission Management	
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	60 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	SoSe
Content	
Literature	Brockhaus, Alles, Luckner: Flugregelung, Springer Verlag, 2011
	R.P.G Collinson: Introduction to Avionics Systems, Springer Verlag, 2011

Course L2375: Mission Management	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0908: Turbo Jet Eng	ines	
	Lecture	
Hrs/wk		
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form		
Examination duration and	45 min	
scale		
Lecturer	Dr. Burkhard Andrich	
Language	DE	
Cycle	WiSe	
Content	 Cycle of the gas turbine Thermodynamics of gas turbine components Wing-, grid- and stage-sizing Operating characteristics of gas turbine components Sizing criteria's for jet engines Development trends of gas turbines and jet engines Maintenance of jet engines 	
Literature	 Bräunling: Flugzeugtriebwerke Engmann: Technologie des Fliegens Kerrebrock: Aircraft Engines and Gas Turbines 	

Course L1514: Structural Mechanics of Fibre Reinforced Composites		
Тур	Lecture	
Hrs/wk		
СР		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Prof. Benedikt Kriegesmann	
Language	EN	
Cycle	WiSe	
Content	Classical laminate theory	
	Rules of mixture	
	Failure mechanisms and criteria of composites	
	Boundary value problems of isotropic and anisotropic shells	
	Stability of composite structures	
	Optimization of laminated composites	
	Modelling composites in FEM	
	Numerical multiscale analysis of textile composites	
	Progressive failure analysis	
Literature	 Schürmann, H., "Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. Wiedemann, J., "Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage. Reddy, J.N., "Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition. Jones, R.M., "Mechanics of Composite Materials", Scripta Book Co., Washington, current edition. Timoshenko, S.P., Gere, J.M., "Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition. Turvey, G.J., Marshall, I.H., "Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition. Herakovich, C.T., "Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition. Mittelstedt, C., Becker, W., "Strukturmechanik ebener Laminate", aktuelle Auflage. 	

Course L1515: Structural Mechanics of Fibre Reinforced Composites	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
	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	 Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7 M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.

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

Course L0949: Materials Testing		
Тур	ecture	
Hrs/wk		
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Dr. Jan Oke Peters	
Language		
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
Examination Form	Klausur
Examination duration and	90 min.
scale	
Lecturer	NN
Language	EN
Cycle	SoSe
Content	Method for calculation and testing of reliability of dynamic machine systems
	 Modeling System identification Simulation Processing of measurement data Damage accumulation Test planning and execution
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	citation Section (small)	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Examination Form	Klausur	
Examination duration and	90 min	
scale		
Lecturer	NN	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0749: Reliability of	Aircraft Systems
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
Language	DE
Cycle	WiSe
Content	 Functions of reliability and safety (regulations, certification requirements) Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment) Reliability analysis of electrical and mechanical systems
Literature	 CS 25.1309 SAE ARP 4754 SAE ARP 4761

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.

Module M1157: Marine Auxiliaries

Courses				
Title		Тур	Hrs/wk	СР
Electrical Installation on Ships (L1531)		Lecture	2	2
Electrical Installation on Ships (L1532)		Recitation Section (large)	1	1
Auxiliary Systems on Board of Ship		Lecture	2 1	2 1
Auxiliary Systems on Board of Ship		Recitation Section (large)	1	1
	Prof. Christopher Friedrich Wirz			
Admission Requirements	None			
Recommended Previous				
Knowledge		and the fall of the state of the second s		
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	The students are able to			
	 name the operating behaviour of const 	umers,		
	describe special requirements on the d	lesign of supply networks and to the electrical	equipment in isola	ted networks, as e
	onboard ships, offshore units, factories	and emergency power supply systems,		
	explain power generation and distribut	ion in isolated grids, wave generator systems	on ships,	
	name requirements for network protec	tion, selectivity and operational monitoring,		
	 name the requirements regarding mari 	ine equipment and apply to product developm	ent, as well as	
	describe operating procedures of equ	ipment components of standard and speciali	zed ships and der	ive requirements f
	product development.			
Skills	Students are able to			
	calculate short-circuit currents, switchgear,			
	design electrical propulsion systems for ship	os		
	• design additional machinery components, a	s well as		
	 to apply basic principles of hydraulics and to 	o develop hydraulic systems.		
Personal Competence				
Social Competence	The students are able to communicate and	cooperate in a professional environment in t	he shipbuilding an	nd component supp
	industry.			
Autonomy	The widespread scope of goined knowledge	enables the students to handle situations in th	air futura profossia	n independently a
Autonomy	confidently.			in multiplenuently a
	connucrity.			
Workload in Hours	Independent Study Time 96, Study Time in Le	ecture 84		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Naval Architecture and Ocean Engineering: C	ore qualification: Elective Compulsory		
Following Curricula		al Complementary Course: Elective Compulsory	,	

Course L1531: Electrical Inst	allation on Ships
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	 performance in service of electrical consumers. 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. power generation and distribution in isolated networks, shaft generators for ships calculation of short circuits and behaviour of switching devices protective devices, selectivity monitoring electrical Propulsion plants for ships
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 Inst	ourse L1532: Electrical Installation on Ships	
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	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 Syst	Course L1249: Auxiliary Systems on Board of Ships	
Тур	ecture	
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	joSe	
Content	 Vorschriften zur Schiffsausrüstung Ausrüstungsanlagen auf Standard-Schiffen Ausrüstungsanlagen auf Spezial-Schiffen Grundlagen und Systemtechnik der Hydraulik Auslegung und Betrieb von Ausrüstungsanlagen 	
Literature	 H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik H. Watter: Hydraulik und Pneumatik 	

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

Courses				
Title		Тур	Hrs/wk	СР
Analysis of Maritime Systems (L00)	58)	Lecture	2	2
Analysis of Maritime Systems (L00)		Recitation Section (small)	1	1
Introduction to Maritime Technolog		Lecture	2	2
Introduction to Maritime Technolog	y (L1614)	Recitation Section (small)	1	1
Module Responsible	Prof. Moustafa Abdel-Maksoud			
Admission Requirements	None			
Recommended Previous	Solid knowledge and competences in med	hanics, fluid dynamics and analysis (ser	ies, periodic	functions, continu
Knowledge	differentiability, integration, multiple variables conditions and eigenvalue problems).	5, ordinaray and partial differential equation	ns, boundary v	value problems, init
Educational Objectives	After taking part successfully, students have rea	ached the following learning results		
Professional Competence				
Knowledge	Knowledge After successful completion of this class, students should have an overview about phenomena and methods in ocean and the ability to apply and extend the methods presented.		in ocean engineer	
	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 system 	vstems,		
	 Modeling and evaluation of dynamic syst 	ems,		
	 System-oriented thinking, decomposition 	of complex systems.		
Skills	s The students learn the ability of apply and transfer existing methods and techniques on novel questions in maritime technolo Furthermore, limits of the existing knowledge and future developments will be discussed.		naritime technologi	
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 a thus promote an important working technicque of subsequent working days. The collaboration has to be illustrated in a commun presentation of the results.			
Autonomy	The course contents are absorbed in an exercise work in a group and individually checked in a final exam in which a self-reflect of the learned is expected without tools.			
Workload in Hours	Independent Study Time 96, Study Time in Lect	ure 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			-
Examination duration and	180 min			
scale				
Assignment for the	Naval Architecture and Ocean Engineering: Core	e qualification: Compulsory		
Following Curricula	Theoretical Mechanical Engineering: Technical G	Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisat	ion Maritime Technology: Elective Compulsory		

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

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

Course L0070: Introduction t	ourse L0070: Introduction to Maritime Technology		
Тур	Lecture		
Hrs/wk	2		
CP	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Dr. Walter Kuehnlein, Dr. Sven Hoog		
Language	DE		
Cycle	WiSe		
Content	1. Introduction		
	 Ocean Engineering and Marine Research The potentials of the seas 		
	Industries and occupational structures		
	2. Coastal and offshore Environmental Conditions		
	 Physical and chemical properties of sea water and sea ice 		
	Flows, waves, wind, ice		
	• Biosphere		
	3. Response behavior of Technical Structures		
	4. Maritime Systems and Technologies		
	General Design and Installation of Offshore-Structures		
	Geophysical and Geotechnical Aspects		
	Fixed and Floating Platforms		
	Mooring Systems, Risers, Pipelines		
	Energy conversion: Wind, Waves, Tides		
Literature			
	 Chakrabarti, S., Handbook of Offshore Engineering, vol. I/II, Elsevier 2005. Gerwick, B.C., Construction of Marine and Offshore Structures, CRC-Press 1999. 		
	 Gerwick, B.C., Construction of Marine and Offshore Structures, CRC-Press 1999. Wagner, P., Meerestechnik, Ernst&Sohn 1990. 		
	 Wagner, P., Meerestechnik, Enstason 1990. Clauss, G., Meerestechnische Konstruktionen, Springer 1988. 		
	 Clauss, G., Meerestechnische Konstruktionen, springer 1966. Knauss, J.A., Introduction to Physical Oceanography, Waveland 2005. 		
	 Wright, J. et al., Waves, Tides and Shallow-Water Processes, Butterworth 2006. 		
	 Faltinsen, O.M., Sea Loads on Ships and Offshore Structures, Cambridge 1999. 		
	- Futurisen, one, sea coas on sinps and onshore searcheres, campilage 1995.		

Course L1614: Introduction t	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	

Courses				
Title		Тур	Hrs/wk	СР
Fatigue Strength of Ships and Offs	nore Structures (L1521)	Lecture	2	3
Fatigue Strength of Ships and Offs	nore Structures (L1522)	Recitation Section (small)	2	3
Module Responsible	Prof. Sören Ehlers			
Admission Requirements	None			
Recommended Previous	Structural analysis of ships and/or offsho	pre structures and fundamental knowledge in mech	anics and mechani	ics of materials
Knowledge				
Educational Objectives	After taking part successfully, students I	nave reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	describe fatigue loads and stress			
	 describe structural behaviour und 	ler cyclic loads.		
Skills	Students are able to calculate life prediction based on the S-N approach as well as life prediction based on the crack propagatio			
Personal Competence				
Social Competence		and cooperate in a professional environment in	the shipbuilding ar	nd component sup
	industry.			
Autonomy	The widespread scope of gained knowle	dge enables the students to handle situations in th	eir future professi	on independently a
	confidently.			
	Independent Study Time 124, Study Tim	ne in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Naval Architecture and Ocean Engineeri	ng: Core qualification: Elective Compulsory		
Following Curricula	Ship and Offshore Technology: Core qua	lification: Elective Compulsory		
	Theoretical Mechanical Engineering: Teo	hnical Complementary Course: Elective Compulsor	у	
	Theoretical Mechanical Engineering: Spe	ecialisation Maritime Technology: Elective Compulse	orv	

Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	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 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

Course L1522: Fatigue Stren	urse L1522: Fatigue Strength of Ships and Offshore Structures	
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
Workload in Hours	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	

Courses				
		-		
Title Marine Geotechnics (L0548)		Typ Lecture	Hrs/wk	СР 2
Marine Geotechnics (L0549)		Recitation Section (large)	2	2
Steel Structures in Foundation and	Hydraulic Engineering (L1146)	Lecture	2	2
Module Responsible	Prof. Jürgen Grabe			
Admission Requirements				
Recommended Previous	complete modules: Geotechnics I-III, Mathe	ematics I-III		
Knowledge				
	courses: Soil laboratory course			
Educational Objectives	After taking part successfully, students have	ve reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 110, Study Time i	in Lecture 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Civil Engineering: Specialisation Geotechni	cal Engineering: Compulsory		
Following Curricula	Civil Engineering: Specialisation Structural	Engineering: Elective Compulsory		
	Civil Engineering: Specialisation Coastal En	ngineering: Compulsory		
	Theoretical Mechanical Engineering: Specia	alisation Maritime Technology: Elective Compulsor	/	
		ical Complementary Course: Elective Compulsory		
	Water and Environmental Engineering: Spe			
	• • •	ecialisation Environment: Elective Compulsory		
	Water and Environmental Engineering: Spe	ecialisation Water: Elective Compulsory		

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

Course L0549: Marine Geotechnics	
Тур	Recitation Section (large)
Hrs/wk	2
СР	2
Workload in Hours	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 Structur	ourse L1146: Steel Structures in Foundation and Hydraulic Engineering		
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Frank Feindt		
Language	DE		
Cycle	SoSe		
Content	Design of a sheet pile wall, design of a combined sheet pile wall, piles, walings, connections, fatigue		
Literature	EAU 2012, EA-Pfähle, EAB		

	Тур		Hrs/wk	СР
	Lecture		2	3
	Recitation See	ction (small)	2	3
e				
r taking part successfully, students hav	e reached the following learning re	aculte		
r taking part successionly, statemes nat	reaction the following learning re	.50105		
students are able to				
		•	•	
way;				
 estimate the potential of digitisation 	in maritime shipping.			
students are able to				
 determine the mode of transport, ac 	tors and functions of the actors in t	the maritime supr	oly chain;	
				on;
 record, map and systematically ar 	alyse material and information f	ows of a maritim	ne logistics cha	in, identify possib
problems and recommend solutions;	;			
 perform risk assessments of human 	disruptions to the supply chain;			
 apply different process modelling me 	ethods in a hitherto unknown field o	of activity and to	work out the res	pective advantage
students are able to				
 discuss and organise extensive work 	c packages in groups:			
students are capable to				
research and select technical literate	ure, including standards and guidel	ines;		
 submit own shares in an extensive v 	vritten elaboration in small groups i	in due time.		
anendent Study Time 124. Study Time i	n Lecture 56			
pendent study nine 124, study nine i				
pulsory Bonus Form	Description			
15 % Subject theoretic	al andTeilnahme an einem Plans	piel und anschlief	Sende schriftlich	e Ausarbeitung
practical work				
ten exam				
Engineering: Specialisation Coastal En	gineering: Elective Compulsory			
rnational Management and Engineering	3: Specialisation II. Logistics: Electiv	e Compulsory		
	-			
			lsory	
	e students are able to present the actors involved in the m name common cargo types in shippi explain operating forms in maritime weigh the advantages and disadvani present relevant factors for the loca way; estimate the potential of digitisation estudents are able to determine the mode of transport, ace identify possible cost drivers in a tra record, map and systematically an problems and recommend solutions; perform risk assessments of human analyse accidents in the field of mar deal with current research topics in t apply different process modelling me estudents are able to discuss and organise extensive work document and present the elaborate estudents are capable to research and select technical literatu submit own shares in an extensive w rependent Study Time 124, Study Time i T5 % Subject theoretic practical work titten exam D minutes iII Engineering: Specialisation Coastal En ernational Management and Engineering gistics, Infrastructure and Mobility: Speci pistics, Infrastructure and Mobility: Speci pistics, Infrastructure and Mobility: Speci pistical Mechanical Engineering: Specialisation Wind E eoretical Mecha	Typ Lecture Recitation Se f. Carlos Jahn ne er taking part successfully, students have reached the following learning rest estudents are able to e present the actors involved in the maritime transport chain with regard name common cargo types in shipping and classify cargo to the correst explain operating forms in maritime shipping, transport options and mes weigh the advantages and disadvantages of the various modes of hints present relevant factors for the location planning of ports and seapo way; e students are able to determine the mode of transport, actors and functions of the actors in 1 i dentify possible cost drivers in a transport chain and recommend appr record, map and systematically analyse material and information fl problems and recommend solutions; perform risk assessments of human disruptions to the supply chain; analyse accidents in the field of maritime logistics and evaluating their deal with current research topics in the field of maritime logistics in a d apply different process modelling methods in a hitherto unknown field sudents are able to e discuss and organise extensive work packages in groups; document and present the elaborated results. e students are capable to e research and select technical literature, including standards and guidel submit own shares in an extensive written elaboration in small groups i submit own shares in an extensive written elaboration in small groups i practical work iten exam Is % Subject theoretical and Teilnahme an einem Plans practical work ite	Typ Lecture Recitation Section (small) f. Carlos Jahn ne er taking part successfully, students have reached the following learning results e students are able to • present the actors involved in the maritime transport chain with regard to their typical to • explain operating forms in maritime shipping, transport options and management in tran • weigh the advantages and disadvantages of the various modes of hinterland transport a • present relevant factors for the location planning of ports and seaport terminals and of way; • estimate the potential of digitisation in maritime shipping. • determine the mode of transport, actors and functions of the actors in the maritime supp • identify possible cost drivers in a transport chain and recommend appropriate proposals • record, map and systematically analyse material and information flows of a maritim problems and recommend solutions; • perform risk assessments of human disruptions to the supply chain; • analyse accidents in the field of maritime logistics and evaluating their relevance in ever • deal with current research topics in the field of maritime logistics in a differentiated way; • apply different process modelling methods in a hitherto unknown field of activity and to • discuss and organise extensive work packages in groups; • document and present the elaborated results. • students are capable to • research and select technical literature, including standards and guidelines; • subdents are capable to	Lecture 2 Recitation Section (small) 2 A. Carlos jahn 2 ne 2 entaking part successfully, students have reached the following learning results 2 entaking part successfully, students have reached the following learning results 2 entaking part successfully, students have reached the following learning results 2 entaking part successfully, students have reached the following learning results 3 explain operating forms in maritime shipping, transport options and management in transport networks; 4 explain operating forms in maritime shipping, transport options and management in transport networks; 4 explain operating forms in maritime shipping, transport options and management in transport networks; 4 explain approximate factors for the location planning of ports and seaport terminals and discuss them in way; 4 e students are able to 4 othermine the mode of transport, actors and functions of the actors in the maritime supply chain; 4 identify possible cost drivers in a transport chain and recommend appropriate proposals for cost reductify 6 proferm risk assessments of human disruptions to the supply chain; 4 analyse accidents in the field of maritime logistis:

Course L0063: Maritime Tran	isport
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	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	 Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005. Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009. Stopford, Martin. Maritime Economics Routledge, 2009

Course L0064: Maritime Tran	isport
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 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	 Stopford, Martin. Maritime Economics Routledge, 2009 Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005. Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009.

Courses	
Title	Typ Hrs/wk CP
Port Logistics (L0686)	Lecture 2 3 Recitation Section (small) 2 3
Port Logistics (L1473)	
Module Responsible	
Admission Requirements Recommended Previous	
Knowledge	
-	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Th
	After completing the module, students can
	After completing the module, students can
	 reflect on the development of seaports (in terms of the functions of the ports and the corresponding terminals, as well as relevant operator models) and place them in their historical context; explain and evaluate different types of seaport terminals and their specific characteristics (cargo, transhipm technologies, logistic functional areas); analyze common planning tasks (e.g. berth planning, stowage planning, yard planning) at seaport terminals and deve suitable approaches (in terms of methods and tools) to solve these planning tasks; identify future developments and trends regarding the planning and control of innovative seaport terminals and disc them in a problem-oriented manner.
Skills	 After completing the module, students will be able to recognize functional areas in ports and seaport terminals; define and evaluate suitable operating systems for container terminals; perform static calculations with regard to given boundary conditions, e.g. required capacity (parking spaces, equipm requirements, quay wall length, port access) on selected terminal types; reliably estimate which boundary conditions influence common logistics indicators in the static planning of selected term types and to what extent.
Personal Competence Social Competence	 After completing the module, students can transfer the acquired knowledge to further questions of port logistics; discuss and successfully organize extensive task packages in small groups; in small groups, document work results in writing in an understandable form and present them to an appropriate extent.
Autonomy	 After completing the module, the students are able to research and select specialist literature, including standards, guidelines and journal papers, and to develop the containdependently; submit own parts in an extensive written elaboration in small groups in due time and to present them jointly within a fitime frame.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
	6
Course achievement	Compulsory Bonus Form Description
	No 15 % Written elaboration
Examination	Written exam
Examination duration and	120 minutes
scale	
-	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory
Following Curricula	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

ourse L0686: Port Logistics	
Тур	Lecture
Hrs/wk	2
CP	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 is 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 deal with the planning, control, execution and monitoring of material flows and the associated information flows in the port system an its interfaces to numerous actors inside and outside the port area. The aim of the lecture Port Logistics is to convey a understanding of structures and processes in ports. The focus will be on different types of terminals, their characteristical layout 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 topic 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	 Alderton, Patrick (2013). Port Management and Operations. Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium. Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005. Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen. Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele. Jahn, Carlos; Saxe, Sebastian (Hg.). Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag, 2017. Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft Lun, Y.H.V. and Lai, KH. and Cheng, T.C.E. (2010). Shipping and Logistics Management. Woitschützke, Claus-Peter (2013). Verkehrsgeografie.

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	 Alderton, Patrick (2013). Port Management and Operations. Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium. Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. (2005) Berlin Heidelberg: Springer-Verlag. Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen. Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele. Jahn, Carlos; Saxe, Sebastian (Hg.) (2017) Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag. Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft Lun, Y.H.V. and Lai, KH. and Cheng, T.C.E. (2010). Shipping and Logistics Management. Woitschützke, Claus-Peter (2013). Verkehrsgeografie.

Module M1021: Marin	e Diesel Engine Plants			
Courses				
Title		Тур	Hrs/wk	СР
Marine Diesel Engine Plants (L0637		Lecture	3	4
Marine Diesel Engine Plants (L0638	3)	Recitation Section (large)	1	2
Module Responsible	Prof. Christopher Friedrich Wirz			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students hav	e reached the following learning results		
Professional Competence				
Knowledge	Students can			
	• explain different types four / two-stroke e	ngines and assign types to given engines,		
	 name definitions and characteristics, as w 	vell as		
	elaborate on special features of the heavy oil operation, lubrication and cooling.			
Skills	kills Students can			
	• evaluate the interaction of ship, engine an	nd propeller,		
	• use relationships between gas exchange,	flushing, air demand, charge injection and combu	stion for the desi	gn of systems,
	design waste heat recovery, starting syste	ems, controls, automation, foundation and design	machinery space	es , and
	 apply evaluation methods for excited mot 	or noise and vibration.		
Personal Competence				
Social Competence	The students are able to communicate an industry.	d cooperate in a professional environment in th	e shipbuilding an	nd component supp
Autonomy	The widespread scope of gained knowledge confidently.	e enables the students to handle situations in the	r future professio	on independently a
Workload in Hours	Independent Study Time 124, Study Time in	n Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Energy Systems: Specialisation Energy Syst	ems: Elective Compulsory		
Following Curricula	Energy Systems: Specialisation Marine Engi	neering: Compulsory		
	Naval Architecture and Ocean Engineering:	Core qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Techni	cal Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specia	lisation Maritime Technology: Elective Compulsor	ý	

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

Course L0638: Marine Diesel	ourse L0638: Marine Diesel Engine Plants	
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	2	
Workload in Hours	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	

Courses					
Title		Тур	Hrs/wk	СР	
Hydrodynamics of High Speed Wat	er Vehicles (L1593)	Lecture	3	3	
Special Topics of Ship Propulsion (I	_1589)	Lecture	3	3	
Module Responsible	Prof. Moustafa Abdel-Maksoud				
Admission Requirements	None				
Recommended Previous	Basic knowledge on ship resistance, shi	p propulsion and propeller theory			
Knowledge					
Educational Objectives	After taking part successfully, students	have reached the following learning results			
Professional Competence					
Knowledge	 Understand present research gur 	estions in the field of ship propulsion			
	 Explain the present state of the a 				
	 Apply given methodology to approach given problems Evaluate the limits of the present ship propulsion systems 				
	 Evaluate the limits of the present ship propulsion systems Identify possibilities to extend present methods and technologies 				
	 Identify possibilities to extend present methods and technologies Evaluate the feasibility of further developments 				
	· Evaluate the reasibility of further	developments			
Skills	Students are able to				
	 select and apply suitable computing 	and simulation methods to determine the hyd	Irodynamic characteristi	cs of ship propulsi	
	systems				
	 model the behavior of ship propulsion 	systems under different operation conditions l	by using simplified meth	ods	
	 evaluate critically the investigation re 	sults of experimental or numerical investigatio	ns		
Personal Competence					
Social Competence	Students are able to				
	 solve problems in beterogeneous 	groups and to document the corresponding re	sculte		
	 share new knowledge with group 		-50105		
	s share new knowledge with group	members			
Autonomy	Students are able to assess their knowle	edge by means of exercises and case studies			
Workload in Hours	Independent Study Time 96, Study Time	e in Lecture 84			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	180 min				
scale					
Assignment for the	Naval Architecture and Ocean Engineer	ing: Core qualification: Elective Compulsory			
Following Curricula	Theoretical Mechanical Engineering: Te	chnical Complementary Course: Elective Comp	ulsory		
	Theoretical Mechanical Engineering: Sp	ecialisation Maritime Technology: Elective Com	nulsory		

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

Course L1589: Special Topics	- of this Desculsion	
	Lecture	
Hrs/wk		
CP		
	Independent Study Time 48, Study Time in Lecture 42 Prof. Moustafa Abdel-Maksoud	
Language		
Cycle	5056	
Content	1. Propeller Geometry	
	2. Cavitation	
	3. Model Tests, Propeller-Hull Interaction	
	4. Pressure Fluctuation / Vibration	
	5. Potential Theory	
	6. Propeller Design	
	7. Controllable Pitch Propellers	
	8. Ducted Propellers	
	9. Podded Drives	
	10. Water Jet Propulsion	
	11. Voith-Schneider-Propulsors	
Literature	 Breslin, J., P., Andersen, P., Hydrodynamics of Ship Propellers, Cambridge Ocean Technology, Series 3, Cambridge University Press, 1996. Lewis, V. E., ed., Principles of Naval Architecture, Volume II Resistance, Propulsion and Vibration, SNAME, 1988. N. N., International Confrrence Waterjet 4, RINA London, 2004 N. N., 1st International Conference on Technological Advances in Podded Propulsion, Newcastle, 2004 	

Courses			
Fitle	Тур	Hrs/wk	СР
Module Responsible	Prof. Robert Seifried		
Admission Requirements	None		
Recommended Previous	see FSPO		
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	see FSPO		
Autonomy	see FSPO		
Workload in Hours	Depends on choice of courses		
Credit points	6		
Assignment for the	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elec	ctive Compulsory	
Following Curricula	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Con	npulsory	
	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 Con	1	
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective C	1	
	Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulso	ory	

Courses				
Title		Тур	Hrs/wk	СР
Numerical Methods in Ship Design	L1271)	Lecture	2	4
Numerical Methods in Ship Design	L1709)	Project-/problem-based Learning	2	2
Module Responsible	Prof. Stefan Krüger			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached the followi	ng learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	45 min			
scale				
Assignment for the	Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory			
-	Theoretical Mechanical Engineering: Technical Complementary (
2	Theoretical Mechanical Engineering: Specialisation Maritime Tec			

Course L1271: Numerical Me	urse L1271: Numerical Methods in Ship Design		
Тур	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	SoSe		
Content	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		
Literature	Mass distributions and longitudinal strength Hullform Design by CFD- techniques Propulsor and Rudder Design by CFD Techniques Skript zur Vorlesung.		

Course L1709: Numerical Me	ourse L1709: Numerical Methods in Ship Design	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
CP	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: Ship	/ibration			
Courses				
Title		Тур	Hrs/wk	СР
Ship Vibration (L1528)		Lecture	2	3
Ship Vibration (L1529)		Recitation Section (small)	2	3
Module Responsible	Dr. Rüdiger Ulrich Franz von Bock und Polach			
Admission Requirements	None			
Recommended Previous	Mechanis I - III			
Knowledge	Structural Analysis of Ships I			
	Fundamentals of Ship Structural Design			
Educational Objectives	After taking part successfully, students have reach	ned 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 natu frequencies and forced vibrations of sructural components and the entire hull girder; they understand the effect of exciting for 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 ship structures including their assessment; they can model structures for the vibration analysis			
Personal Competence				
Social Competence	The students are able to communicate and coop industry.	erate in a professional environment in th	ne shipbuilding an	d component supp
Autonomy	Students are able to detect vibration-prone comp and to assess the results	oonents on ships, to model the structure,	to select suitable	calculation metho
Workload in Hours	Independent Study Time 124, Study Time in Lectu	re 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	3 hours			
scale				
Assignment for the	Energy Systems: Specialisation Marine Engineering	g: Elective Compulsory		
Following Curricula	Naval Architecture and Ocean Engineering: Core q	ualification: Compulsory		
	Ship and Offshore Technology: Core qualification:	Compulsory		
	Theoretical Mechanical Engineering: Specialisation		-	
	Theoretical Mechanical Engineering: Technical Cor	nplementary Course: Elective Compulsory		

Course L1528: Ship Vibration	1
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach
Language	EN
Cycle	WiSe
Content	1. Introduction; assessment of vibrations
	2. Basic equations
	3. Beams with discrete / distributed masses
	4. Complex beam systems
	5. Vibration of plates and Grillages
	6. Deformation method / practical hints / measurements
	7. Hydrodynamic masses
	8. Spectral method
	9. Hydrodynamic masses acc. to Lewis
	10. Damping
	11. Shaft systems
	12. Propeller excitation
	13. Engines
Literatura	Siehe Verlegungsschriet
Literature	Siehe Vorlesungsskript

Course L1529: Ship Vibration	1
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach
Language	EN
Cycle	WiSe
Content	1. Introduction; assessment of vibrations
	2. Basic equations
	3. Beams with discrete / distributed masses
	4. Complex beam systems
	5. Vibration of plates and Grillages
	6. Deformation method / practical hints / measurements
	7. Hydrodynamic masses
	8. Spectral method
	9. Hydrodynamic masses acc. to Lewis
	10. Damping
	11. Shaft systems
	12. Propeller excitation
	13. Engines
Literature	Siehe Vorlesungsskript

ourses				
itle		Тур	Hrs/wk	СР
inear and Nonlinear Waves (L1737)	Project-/problem-based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Good Knowledge in Mathematics, Mechanics and Dynamics.			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the foll	owing learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts in Wave M	Aechanics and to develop and research	new terms and	concepts.
Skills	Students are able to apply existing methods and procesures of Wa	ve Mechanics and to develop novel me	thods and proc	edures.
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks individually an	d to identify and follow up novel resear	ch tasks by the	mselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Mechatronics: Specialisation System Design: Elective Compu	lsory		
Following Curricula	Naval Architecture and Ocean Engineering: Core qualification	a: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Maritime			
	Theoretical Mechanical Engineering: Technical Complementa	ry Course: Elective Compulsory		

Course L1737: Linear and No	Course L1737: Linear and Nonlinear Waves		
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, Dr. Antonio Papangelo		
Language	DE/EN		
Cycle	WiSe		
Content	Introduction into the Dynamics of Linear and Nonlinear Waves.		
Literature	G.B. Witham, Linear and Nonlinear Waves. Wiley 1999.		
	C.C. Mei, Theory and Applications of Ocean Surface Waves. World Scientific 2004.		

Module M1148: Selected topics in Naval Architecture and Ocean Engineering

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Outfitting and Operation of Special Purpose Offshore Ships (L1896)Lecture23Design of Underwater Vessels (L0670)Lecture23Disting of Underwater Vessels (L0670)Lecture23Modeling and Simulation of Maritime Systems (L2013)Project/problem-based Learning23Offshore Wind Parks (L0072)Lecture23Ship Acoustics (L1605)Lecture23Ship Appring (L0352)Lecture23Selected Topics of Experimental and Theoretical Fluiddynamics (L0240)Lecture23Technology of Naval Surface Vessels(D765)Lecture23Technology of Naval Surface VesselsNone	Courses				
Design of Underwater Vessels (L0670)Lecture23Lattice-Boltzmann methods for the simulation of free surface flows (L2066)Lecture23Offshore Wind Parks (L0072)Lecture23Ship Acoustics (L1605)Lecture23Ship Acoustics (L1605)Lecture23Ship Acoustics (L1605)Lecture23Selected Topics of Experimental and Theoretical Fluiddynamics (L0240)Lecture23Selected Topics of Experimental sufficied Mechanics of Saling Ships (L0873)Lecture23Technical Elements and Fluid Mechanics of Saling Ships (L0873)Lecture23Module ResponsibeProf. Soren EhlersLecture23Admission Requirements KnowledgeNone	Title	Тур	н	rs/wk	СР
Lattice-Boltzmann methods for the simulation of free surface flows (L2066) Lecture 2 3 Modeling and Simulation of Martim- 5 yogenes (L2013) Project-/problem-based Learning 2 3 Ship Acoustics (L1605) Lecture 2 3 Ship Acoustics (L075) Lecture 2 3 Ship Acoustics (L075) Lecture 2 3 Technology of Naval Surface Vessel: (L075) Lecture 2 3 Technology of Naval Surface Vessel: (L075) Lecture 2 3 Modeline Responsible Prof. Soren Ehlers Model Responsible None Recommended Previous none Knowledge 1 Professional Competence Acting part successfully, students have reached the following learning results Professional Competence Acting part successfully, students have reached the following learning results Professional Competence Situe Acting part successfully, students have reached the following learning results Foreface and Dejectives Acting part successfully, students have reached the following learning results Foreface and the interval are able to find their way through selected special areas within naval architecture and ocean engineering i Students are able to explain basic models and procedures in selected special areas. Students are able to apply basic methods in selected areas of ship and ocean engineering. Social Competence Situents are able to communicate and cooperate in a professional environment in the shipbuilding and component supp industry. Autonomy Sudents can chose independently, in which fields they want to kere their knowledge and skills through the kert of accurses Workload in Huans Depends on choice of courses Workload in Huans Marchitecture and Ocean Engineering: Core qualification: Elettive Compulsory Following Curricute Maxia Architecture and Ocean Engineering: Core qualification: Elettive Compulsory Following Curricute Through Technology: Elective Compulsory	Outfitting and Operation of Special	Purpose Offshore Ships (L1896) Lecture	2		3
Modeling and Simulation of Maritime Systems (L2013)Project-/problem-based Learning 23Offshore Wind Park's (L0072)Lecture23Ship Acoustics (L0650)Lecture23Ship Dynamics (L0352)Lecture23Selected Topics of Experimental and Theoretical Fluiddynamics (L0240)Lecture23Technical Elements and Fluid Mechanics of Saling Ships (L0873)Lecture23Technical Elements and Fluid Mechanics of Saling Ships (L0873)Lecture23Module Responsiblerof. Sören EhlersNore3Admission RequirementsNoneRecommended Previous nonenonesite taking part successfully, students have reached the following learning resultssite taking part successfully, students have reached the following learning resultsProfessional Competence Social Competencesituents are able to find their way through selected special areas within naval architecture and ocean engineering • Students are able to explain basic models and procedures in selected special areas. • Students are able to apply basic methods in selected areas of ship and ocean engineering.Situents are able to communicate and cooperate in a professional environment in the shipbuilding and component sup industry.AutonomStudents are able to communicate and cooperate in a professional environment in the shipbuilding and coustersVorkload in HoursDenetics of coursesVorkload in HoursSidents and able of coursesVorkload in HoursNaval Architecture and Ocean Engineering: Core qualification: Elective Compulsory<	Design of Underwater Vessels (L06	70) Lecture	2		3
Offshore Wind Parks (L0072) Lecture 2 3 Ship Acoustics (L055) Lecture 2 3 Ship Dynamics (L0532) Lecture 2 3 Selected Topics of Experimental and Tworetical Fluiddynamics (L0240) Lecture 2 3 Technology of Naval Surface Versews: (L0753) Lecture 2 3 Technology of Naval Surface Versews: (L0755) Lecture 2 3 Technology of Naval Surface Versews: (L0755) Lecture 2 3 Module Responsible Prof. Sören Ehlers Lecture 2 3 Recommended Previous none	Lattice-Boltzmann methods for the	simulation of free surface flows (L2066) Lecture	2		3
Ship Acoustics (L1605)Lecture23Ship Dynamics (L0352)Lecture23Selected Topics of Experimental and Theoretical Fluiddynamics (L0240)Lecture23Technical Elements and Fluid Mechacis of Salling Ships (L0873)Lecture23Technology of Naval Surface Vessel(L0765)Lecture23Module RegonsibeProf. Sören EhlersLecture23Admission Requirementsnone	Modeling and Simulation of Maritim	ne Systems (L2013) Project-/problem-base	ed Learning 2		3
Ship Dynamics (L0352)Lecture23Selected Topics of Experimental arr Hoeretical Fluidynamics (L0240)Lecture23Technical Elements and Fluid Mechanics of Saling Ships (L0873)Lecture23Technidgy of Naval Surface Vessel(D765)Lecture23Module ResponsibleProf. Sören EhlersLecture23Recommended Previous Knowledgenone	Offshore Wind Parks (L0072)	Lecture	2		3
Selected Topics of Experimental and Theoretical Fluiddynamics (L0240) Lecture 2 3 Technical Elements and Fluid Mechanics of Salling Ships (L0873) Lecture 2 3 Technology of Naval Surface Vessel: (D765) Lecture 2 3 Module Responsible Prof. Sören Ehlers Inc. In	Ship Acoustics (L1605)	Lecture	2		3
Technical Elements and Fluid Mechanical Saling Ships (L0873) Lecture 2 3 Technology of Naval Surface Vesse: (L0765) Lecture 2 3 Module Responsible Prof. Sören Ehlers International Soling Ships (L0873) Lecture 2 3 Admission Requirements None International Soling Ships (L0873) International Soling Soli	Ship Dynamics (L0352)	Lecture	2		3
Technology of Naval Surface Vessels Lecture 2 3 Module Responsible Prof. Sören Ehlers Inclusion Requirements None Admission Requirements None Inclusion Recommended Previous none Recommended Previous none Inclusion Requirements None Feducational Objectives After taking part successfully, students have reached the following learning results Inclusion Recommended Previous Professional Competence Inclusion are able to find their way through selected special areas within naval architecture and ocean engineering Students are able to explain basic models and procedures in selected special areas. Students are able to apply basic methods in selected areas of ship and ocean engineering. Personal Competence Students are able to communicate and cooperate in a professional environment in the shipbuilding and component supp industry. Autonom Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses Credit points 6 Assignment for the Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Following Curricula Naval Architecture and Ocean Engineering: Specialisation Maritime Technology: Elective Compulsory	Selected Topics of Experimental an	d Theoretical Fluiddynamics (L0240) Lecture	2		3
Module Responsible Prof. Sören Ehlers Admission Requirements None Recommended Previous none Knowledge After taking part successfully, students have reached the following learning results Professional Competence Knowledge Knowledge • Students are able to find their way through selected special areas within naval architecture and ocean engineering • Students are able to explain basic models and procedures in selected special areas. • Students are able to explain basic models and procedures in selected special areas. Skills Students are able to apply basic methods in selected areas of ship and ocean engineering. Personal Competence Students are able to communicate and cooperate in a professional environment in the shipbuilding and component supp industry. Autonomy Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses Workload in Hours Depends on choice of courses Credit points 6 Assignment for the Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Following Curricula Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory	Technical Elements and Fluid Mech	anics of Sailing Ships (L0873) Lecture	2		3
Admission Requirements None Recommended Previous Knowledge none Knowledge After taking part successfully, students have reached the following learning results Professional Competence Knowledge Students are able to find their way through selected special areas within naval architecture and ocean engineering Students are able to explain basic models and procedures in selected special areas. Students are able to interrelate scientific and technical knowledge. 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 and cooperate in a professional environment in the shipbuilding and component supp industry. Autonomy Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses Vorkload in Hours Depends on choice of courses Credit points 6 Assignment for the Following Curricula Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory	Technology of Naval Surface Vesse	ls (L0765) Lecture	2		3
Recommended Previous Knowledge none Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence Knowledge • Students are able to find their way through selected special areas within naval architecture and ocean engineering • Students are able to explain basic models and procedures in selected special areas. • Students are able to explain basic models and procedures in selected special areas. 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 and cooperate in a professional environment in the shipbuilding and component supp industry. Autonomy Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses Workload in Hours Depends on choice of courses Credit points 6 Assignment for the Following Curricula Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory	Module Responsible	Prof. Sören Ehlers			
KnowledgeEducational ObjectivesAfter taking part successfully, students have reached the following learning resultsProfessional Competence <i>knowledge</i> • Students are able to find their way through selected special areas within naval architecture and ocean engineering • Students are able to explain basic models and procedures in selected special areas. • Students are able to interrelate scientific and technical knowledge.SkillsStudents are able to apply basic methods in selected areas of ship and ocean engineering.Personal Competence Social CompetenceThe students are able to communicate and cooperate in a professional environment in the shipbuilding and component supp industry.AutonomyStudents can chose independently, in which fields they want to deepen their knowledge and skills through the election of coursesWorkload in HoursDepends on choice of coursesCredit points6Assignment for the Following CurriculaNaval Architecture and Ocean Engineering: Core qualification: Elective CompulsoryTheoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory	Admission Requirements	None			
Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence Knowledge Knowledge • Students are able to find their way through selected special areas within naval architecture and ocean engineering • Students are able to explain basic models and procedures in selected special areas. • Students are able to explain basic models and procedures in selected special areas. • Students are able to apply basic methods in selected areas of ship and ocean engineering. • Students are able to apply basic methods in selected areas of ship and ocean engineering. Personal Competence The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supp industry. Autonomy Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses Workload in Hours Depends on choice of courses Credit points 6 Assignment for the Following Curricula Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory	Recommended Previous	none			
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Skills Students are able to apply basic methods in selected areas of ship and ocean engineering. Personal Competence The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supp industry. Autonomy Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses Workload in Hours Depends on choice of courses Credit points 6 Assignment for the Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Following Curricula Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory			ireas.		
Personal Competence The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supplindustry. Autonomy Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses Workload in Hours Depends on choice of courses Credit points 6 Assignment for the Following Curricula Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory		 Students are able to interrelate scientific and technical knowledge. 			
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Social Competence The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supplindustry. Autonomy Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses Workload in Hours Depends on choice of courses Credit points 6 Assignment for the Following Curricula Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory	Personal Competence				
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Autonomy Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses Workload in Hours Depends on choice of courses Credit points 6 Assignment for the Following Curricula Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory	Social Competence		nt in the shipt	building and	component suppl
Workload in Hours Depends on choice of courses Credit points 6 Assignment for the Following Curricula Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Following Curricula Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory		industry.			
Credit points 6 Assignment for the Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Following Curricula Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory	Autonomy	Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses.			
Credit points 6 Assignment for the Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Following Curricula Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory	Workload in Hours	Depends on choice of courses			
Assignment for theNaval Architecture and Ocean Engineering: Core qualification: Elective CompulsoryFollowing CurriculaTheoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory					
Following Curricula Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory					
	-		nnulsory		
	i onowing curricula				

Course L1896: Outfitting and	d Operation of Special Purpose Offshore Ships	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	ündliche Prüfung	
Examination duration and	min	
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 ma-jority 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 en-gaged 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 - Dredgers and rock dumping vessels Chinement of the discussed. Chinement of the addressed of the discussed. Chinement of the addressed of the discussels Chinement of the lecture of the lecture: - Anchor handling and plattform supply vessels - Cable - and pile lay vessels - Dredgers and rock dumping vessels - Dredgers and rock dumping vessels	
Literature	- Diving support vessels 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: Design of Und	lerwater Vessels
Тур	
Hrs/wk	
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	
Examination duration and	30 min
scale	Peter Hauschildt
Language	
Cycle	
Content	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
	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
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
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
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
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		
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	45 min	
scale		
Lecturer	Dr. Alexander Mitzlaff	
Language	DE	
Cycle	WiSe	
Content	 Nonlinear Waves: Stability, pattern formation, solitary states Bottom Boundary layers: wave boundary layers, scour, stability of marine slopes Ice-structure interaction Wave and tidal current energy conversion 	
Literature	 Chakrabarti, S., Handbook of Offshore Engineering, vol. I&II, Elsevier 2005. Mc Cormick, M.E., Ocean Wave Energy Conversion, Dover 2007. Infeld, E., Rowlands, G., Nonlinear Waves, Solitons and Chaos, Cambridge 2000. Johnson, R.S., A Modern Introduction to the Mathematical Theory of Water Waves, Cambridge 1997. Lykousis, V. et al., Submarine Mass Movements and Their Consequences, Springer 2007. Nielsen, P., Coastal Bottom Boundary Layers and Sediment Transport, World Scientific 2005. Research Articles. 	

Course L1605: Ship Acoustics	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Dietrich Wittekind
Language	DE
Cycle	SoSe
Content	
Literature	

Тур	Lecture
Hrs/wk	
HIS/WK	
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
kamination duration and	60 min
scale	
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE
Cycle	
	Maneuverability of ships
	Equations of motion
	Hydrodynamic forces and moments
	Linear equations and their solutions
	Full-scale trials for evaluating the maneuvering performance
	Regulations for maneuverability
	Rudder
	Seakeeping
	Representation of harmonic processes
	Motions of a rigid ship in regular waves
	Flow forces on ship cross sections Strip method
	Strip method Concerning induced by ship metion in regular wayses
	 Consequences induced by ship motion in regular waves Behavior of ships in a stationary sea state
	Long-term distribution of seaway influences
Literature	Abdel-Maksoud, M., Schiffsdynamik, Vorlesungsskript, Institut für Fluiddynamik und Schiffstheorie, Technische Universi
	Hamburg-Harburg, 2014
	 Abdel-Maksoud, M., Ship Dynamics, Lecture notes, Institute for Fluid Dynamic and Ship Theory, Hamburg University Technology, 2014.
	Technology, 2014 • Bertram, V., Practical Ship Design Hydrodynamics, Butterworth-Heinemann, Linacre House - Jordan Hill, Oxford, Uni
	 Bertrann, V., Practical Ship Design Hydrodynamics, Butterworth-Heinemann, Enacte House - Jordan Hin, Oxford, Om Kingdom, 2000
	 Bhattacharyya, R., Dynamics of Marine Vehicles, John Wiley & Sons, Canada,1978
	 Brix, J. (ed.), Manoeuvring Technical Manual, Seehafen-Verlag, Hamburg, 1993
	 Claus, G., Lehmann, E., Östergaard, C). Offshore Structures, I+II, Springer-Verlag. Berlin Heidelberg, Deutschland, 1992
	 Faltinsen, O. M., Sea Loads on Ships and Offshore Structures, Cambridge University Press, United Kingdom, 1990
	 Handbuch der Werften, Deutschland, 1986
	 Jensen, J. J., Load and Global Response of Ships, Elsevier Science, Oxford, United Kingdom, 2001
	 Lewis, Edward V. (ed.), Principles of Naval Architecture - Motion in Waves and Controllability, Society of Naval Architects a
	Marine Engineers, Jersey City, NJ, 1989
	 Lewandowski, E. M., The Dynamics of Marine Craft: Maneuvering and Seakeeping, World Scientific, USA, 2004
	 Lloyd, A., Ship Behaviour in Rough Weather, Gosport, Chichester, Sussex, United Kingdom, 1998

Course L0240: Selected Topics of Experimental and Theoretical Fluiddynamics		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
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.	

Тур	nents and Fluid Mechanics of Sailing Ships Lecture
Hrs/wk	2
CP	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
	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
	- 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	 Vorlesungs-Manuskript mit Literatur-Liste: Verteilt zur Vorlesung B. Wagner: Fahrtgeschwindigkeitsberechnung für Segelschiffe, IfS-Rep. 132, 1967 B. Wagner: Sailing Ship Research at the Hamburg University, IfS-Script 2249, 1976 A.R. Claughton et al.: Sailing Yacht Design 1&2, University of Southampton, 1998 L. Larsson, R.E. Eliasson: Principles of Yacht Design, Adlard Coles Nautical, London, 2000 K. Hochkirch: Entwicklung einer Messyacht, Diss. TU Berlin, 2000

Course L0765: Technology of	f Naval Surface Vessels
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Martin Schöttelndreyer
Language	DE
Cycle	WiSe
Content	 Operational scenarios, tasks, capabilities, requirements Product and process models, rules and regulations Survivability: threats, signatures, counter measures Design characteristics Energy and propulsion systems Command and combat systems Vulnerability: residual strength, residual functionality
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)

Courses				
Title		Тур	Hrs/wk	СР
Ice Engineering (L1607)		Lecture	2	2
Ice Engineering (L1615)		Recitation Section (small)	1	2
Ship structural design for arctic co		Project-/problem-based Learning	2	2
Module Responsible				
Admission Requirements				
Recommended Previous	none			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fo	llowing learning results		
Professional Competence				
Knowledge	The challenges and requirements due to ice can be explained. Ice loads can be explained and ice strengthening can b 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 carr	ied out and presented whereby the	capabilities	to both, present a
	defend, the skills and findings will be achieved.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory			
Following Curricula	Ship and Offshore Technology: Core qualification: Elective C	Compulsory		
	Theoretical Mechanical Engineering: Technical Complement	ary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Maritime	e Technology: Elective Compulsory		

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	
	 Introduction, what is/means ice engineering 	
	 Description of different kinds of ice, main ice properties and different ice failure modes 	
	 Why is ice so different compared to open water 	
	 Presentation of design challenges and requirements for structures and systems in ice covered waters 	
	2. Ice Load Determination and Ice Model Testing	
	 Overview of different empirical equations for simple determination of ice loads 	
	 Discussion and interpretation of the different equations and results 	
	 Introduction to ice model tests 	
	 What are the requirements for ice model tests, what parameters have to be scaled 	
	 What can be simulated and how to use the results of such ice model tests 	
	3. Computational Modelling of Ice-Structure Interaction Processes	
	 Dynamic fracture and continuum mechanics for modelling ice-structure interaction processes 	
	 Alternative numerical crack propagation modelling methods. Examples of cohesive element models for real life structures. 	
	 Discussion of contribution of ice properties, hydrodynamics and rubble. 	
	4. Ice Design Philosophies and Perspectives	
	 What has to be considered when designing structures or systems for ice covered waters 	
	 What are the main differences compared to open water design 	
	◦ Ice Management	
	• What are the main ice design philosophies and why is an integrated concept so important for ice	
	Learning Objectives	
	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		
	Proceedings OMAE	
	Proceedings POAC	
	Proceedings ATC	

Course L1615: Ice Engineering	
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	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 structura	ourse L1575: Ship structural design for arctic conditions	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	ören 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 Manual M.Sc. "Theoretical Mechanical Engineering"

lodule M1165: Ship S	Safety				
Courses					
Title		Тур	Hrs/wk	СР	
ihip Safety (L1267)		Lecture	2	4	
ihip Safety (L1268)		Recitation Section (large)	2	2	
Module Responsible	Prof. Stefan Krüger				
Admission Requirements	None				
Recommended Previous	Ship Design, Hydrostatics, Statistical Proces	ses			
Knowledge					
Educational Objectives	After taking part successfully, students have	e reached the following learning results			
Professional Competence					
Knowledge	The student shall lean to integrate safety as	pects into the ship design process. This includes	he undertsnding	and	
	application of existing rules as well as the u	nderstanding of the sfatey concept and level whic	h is targeted by a	a rule.	
	Further, methods of demonstrating equivale	ent safety levels are introduced.			
Skills	he lectures starts with an overview about de	eneral safety concepts for technical systems. The	maritime safety		
JKIIIS		es and duties. Then, the gerenal difference betwee		hd	
		ferent examples in ship design, the influence of th			
	-	es with respect to the physical background are sh			
		direct calculations are discussed. The following f			
	- Freeboard, water- and weathertight subdiv	-			
	- all aspects of intact stability, including spe	cial problems such as grain code			
	- damage stability for passenger vessels inc	luding Stockholm agreement			
	- damage stbility fopr cargo vessels				
	- on board stability, inclining experiment and	d stability booklet			
	- Relevant manoevering information				
Personal Competence					
Social Competence	The student learns to take responsibilty for	the safety of his designn.			
Autonomy	Responsible certification of technical design	S.			
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	180 min				
scale					
Assignment for the	Naval Architecture and Ocean Engineering:	Core qualification: Compulsory			
Following Curricula	Theoretical Mechanical Engineering: Technic	cal Complementary Course: Elective Compulsory			

Course L1267: Ship Safety	
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Stefan Krüger
Language	DE
Cycle	WiSe
Content	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.
	- 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
	- Relevant manoevering information
Literature	SOLAS, LOAD LINES, CODE ON INTACT STABILITY. Alle IMO, London.

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Course L1268: Ship Safety	
Тур	Recitation Section (large)
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

<u> </u>				
Courses				
Title		Тур	Hrs/wk	СР
Manoeuvrability of Ships (L1597) Shallow Water Ship Hydrodynamic:	s (I 1598)	Lecture Lecture	2	3 3
	Prof. Moustafa Abdel-Maksoud	Lecture	L	5
Admission Requirements				
Recommended Previous				
Knowledge	b.se. seninbud			
5	After taking part successfully, stude	nts have reached the following learning results		
Professional Competence	5,			
	The students lern the motion equation and how to describe hydrodynamic forces. They'll will be able to develop methods analysis of manoeuvring behaviour of ships and explaining the Nomoto equation. The students will know the common model t as well as their assets and drawbacks. Furthermore, the students lern the basics of assessment and prognosis of ship manoeuvrabilit. Basics of characteristics of fi around ships in shallow water regarding ship propulsion and manoeuvrability will be aquired.			common model te
Skills				
Personal Competence				
Social Competence				
Autonomy				
	Independent Study Time 124, Study	Time in Lecture 56		
Credit points				
Course achievement				
	Written exam			
Examination duration and scale	180 min			
	Naval Architecture and Ocean Engin	poring: Corp qualification: Elective Compulson		
-	-	eering: Core qualification: Elective Compulsory qualification: Elective Compulsory		
i onowing curricula		Technical Complementary Course: Elective Comp	ilsory	

Course L1597: Manoeuvrabil	ity of Ships
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	WiSe
Content	 coordinates & degrees of freedom governing equations of motion hydrodynamic forces & moments ruder forces navigation based on linearised eq.of motion(exemplary solutions, yaw stability) manoeuvering test (constraint & unconstraint motion) slender body approximation 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	 Crane, C. L. H., Eda, A. L., Principles of Naval Architecture, Chapter 9, Controllability, SNAME, New York, 1989 Brix, J., Manoeuvring Technical Manual, Seehafen Verlag GmbH, Hamburg 1993 Söding, H., Manövrieren, Vorlesungsmanuskript, Institut für Fluiddynamik und Schiffstheorie, TUHH, Hamburg, 1995

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

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: Polyn	ners				
Courses					
Title		Тур	Hrs/wk	СР	
Structure and Properties of Polyme	rs (L0389)	Lecture	2	3	
Processing and design with polyme	rs (L1892)	Lecture	2	3	
Module Responsible	Dr. Hans Wittich				
Admission Requirements	None				
Recommended Previous	Basics: chemistry / physics / material scie	ence			
Knowledge					
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results			
Professional Competence					
Knowledge	Students can use the knowledge of plastic	cs and define the necessary testing and analys	is.		
	They can explain the complex relationship	ps structure-property relationship and			
		the polymers, including to explain neighboring (contexts (e.g. sustaina	bility, environmenta	
	protection).				
Skills	Students are capable of				
	 using standardized calculation method evaluate the different materials. 	ds in a given context to mechanical proper	ties (modulus, strengt	th) to calculate an	
	- selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resista				
Personal Competence					
Social Competence	Students can				
	- arrive at funded work results in heterogenius groups and document them.				
	- 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.				
	- assess possible consequences of their p	professional activity.			
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	180 min				
Assignment for the	Materials Science: Specialisation Enginee	ring Materials: Elective Compulsory			
Following Curricula	Biomedical Engineering: Specialisation Im	• • •			
J		rtificial Organs and Regenerative Medicine: Elec	tive Compulsory		
		anagement and Business Administration: Electi			
		edical Technology and Control Theory: Elective			
	Product Development, Materials and Prod	duction: Specialisation Production: Elective Com	pulsory		
	Product Development, Materials and Prod	duction: Specialisation Materials: Elective Comp	ulsory		
	Product Development, Materials and Prod	duction: Specialisation Product Development: El	ective Compulsory		
	Theoretical Mechanical Engineering: Tech	nnical Complementary Course: Elective Compul	sory		
	Theoretical Mechanical Engineering: Spec	cialisation Materials Science: Elective Compulso	ory		

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

Course L1892: Processing an	nd design with polymers		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	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		
	signing 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		

Courses			
Fitle	Тур	Hrs/wk	СР
Module Responsible	Prof. Robert Seifried		
Admission Requirements	None		
Recommended Previous	see FSPO		
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	see FSPO		
Autonomy	see FSPO		
Workload in Hours	Depends on choice of courses		
Credit points	6		
Assignment for the	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elec	ctive Compulsory	
Following Curricula	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Con	npulsory	
	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 Con	1	
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective C	1	
	Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulso	ory	

Courses				
Fitle		Тур	Hrs/wk	СР
Structure and properties of fibre-po	lymer-composites (L1894)	Lecture	2	3
Structure and properties of fibre-po	lymer-composites (L2614)	Project-/problem-based Learning	2	2
Structure and properties of fibre-po	lymer-composites (L2613)	Recitation Section (large)	1	1
Module Responsible	Prof. Bodo Fiedler			
Admission Requirements	None			
Recommended Previous	Basics: chemistry / physics / materials science			
Knowledge				
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
Knowledge	Students can use the knowledge of fiber-reinforce	d composites (FRP) and its constituents to p	lay (fiber / m	atrix) and define t
	necessary testing and analysis.			
	They can explain the complex relationships structur	e-property relationship and		
	the interactions of chemical structure of the pol	ymers, their processing with the different	fiber types,	including to expl
	neighboring contexts (e.g. sustainability, environme		, <u>, , , , , , , , , , , , , , , , , , </u>	5 5 5
		•		
Skills	Students are capable of			
	 using standardized calculation methods in a 	given context to mechanical properties (m	odulus streno	ath) to calculate a
	evaluate the different materials.	given concexe to mechanical properties (in	ouulus, streng	
	 approximate sizing using the network theory 	of the structural elements implement and ev	aluate	
	 selecting appropriate solutions for mechanical 			n resistance
	· Selecting appropriate solutions for meenanice	in recycling problems and sizing example still	11035, 00110310	in resistance.
Personal Competence				
Social Competence	Students can			
	 arrive at funded work results in beteregenius 	groups and document them		
	 arrive at funded work results in heterogenius groups and document them. provide appropriate feedback and handle feedback on their own performance constructively. 			
		aback on their own performance construction		
Autonomy	Students are able to			
Autonomy				
	- 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 their own state of learning in specific terms and to define further work steps on this basis.			
	- assess possible consequences of their professiona	activity.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture	2 70		
Credit points	6			
Course achievement	None			
	Written exam			
	90 min			
scale				
	Energy Systems: Core qualification: Elective Compu	lson		
-	Aircraft Systems Engineering: Core qualification: Elective compa	•		
i ononing curricula	, , , , , , , , , , , , , , , , , , , ,		on: Elective Co	ompulsory
	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory			
	Mechanical Engineering and Management: Core qua			
	Product Development, Materials and Production: Sp		ompulsorv	
	Product Development, Materials and Production: Sp			
	Product Development, Materials and Production: Sp			
	Renewable Energies: Specialisation Bioenergy Syste			
	Renewable Energies: Specialisation Wind Energy Sy			
	Renewable Energies: Specialisation Solar Energy Sy			
	Theoretical Mechanical Engineering: Specialisation			

Course L1894: Structure and	properties of fibre-polymer-composites	
	Lecture	
Hrs/wk		
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Bodo Fiedler	
Language	EN	
Cycle		
Content	- Microstructure and properties of the matrix and reinforcing materials and their interaction	
	- Development of composite materials	
	- Mechanical and physical properties	
- Mechanics of Composite Materials		
	- Laminate theory	
- Test methods		
	- Non destructive testing	
	- Failure mechanisms	
	- Theoretical models for the prediction of properties	
	- Application	
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 L2614: Structure and	ourse L2614: Structure and properties of fibre-polymer-composites		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Bodo Fiedler		
Language	DE/EN		
Cycle	SoSe		
Content			
Literature			

Course L2613: Structure and properties of fibre-polymer-composites		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Bodo Fiedler	
Language	EN	
Cycle	SoSe	
Content		
Literature		

Module M1226: Mech	anical Properties			
Courses				
Title		Тур	Hrs/wk	СР
Mechanical Behaviour of Brittle Materials (L1661) Dislocation Theory of Plasticity (L1662)		Lecture	2	3 3
Module Responsible	Dr. Erica Lilleodden			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in Materials Science I/II			
Educational Objectives	After taking part successfully, students h	ave reached the 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 transformation			
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 teacher			eachers.	
	- 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	e in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Materials Science: Core qualification: Cor	npulsory		
Following Curricula		t: Specialisation Materials: 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: Compulsory			
		cialisation Materials Science: Elective Compulso	•	
	Theoretical Mechanical Engineering: Tech	nnical Complementary Course: Elective Compu	sory	

Course L1661: Mechanical Be	ehaviour of Brittle Materials	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Gerold Schneider	
Language	DE/EN	
Cycle	SoSe	
Content	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,	
	Heterogeneous materials II	
	Toughening mechanisms: crack bridging, fibres	
	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	
Literature	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: Dislocation Th	neory of Plasticity
	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Erica Lilleodden
Language	DE/EN
Cycle	SoSe
Content	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. 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

Courses					
Title		Тур	Hrs/wk	СР	
Experimental Micro- and Nanomechanics (L1673)		Lecture	2	4	
Experimental Micro- and Nanomechanics (L1674)		Recitation Section (small)	1	2	
Module Responsible	Dr. Erica Lilleodden				
Admission Requirements	None				
Recommended Previous	Basics in Materials Science I/II, Mechanical Properties, Phenomena and Methods in Materials Science				
Knowledge					
Educational Objectives	After taking part successfully, students have	reached the following learning results			
Professional Competence					
Knowledge	Students are able to describe the principle	s of mechanical behavior (e.g., stress, strain, m	odulus, strengtl	n, hardening, failu	
	fracture).				
	Students can explain the principles of cha	ractorization mothods used for investigating mi	rostructuro (o s		
	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.				
Skille					
JKIII5	Is Students are capable of using standardized calculation methods to calculate and evaluate mechanical properties strength) of different materials under varying loading states (e.g., uniaxial stress or plane strain).				
	strength) of unreferit materials under varyin	y loading states (e.g., dillaxial scress of plane stra			
Personal Competence					
Social Competence	Students can provide appropriate feedback a	and handle feedback on their own performance co	nstructively.		
Autonomy	Students are able to				
Autonomy					
	- assess their own strengths and weaknesses				
	access their own state of learning in specific terms and to define further work state on this basis guided by teachers				
	- 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	o ask for help o	r clarifications wh	
	needed				
Workload in Hours	Independent Study Time 138, Study Time in	Lecture 42			
Credit points					
Course achievement					
Examination					
Examination duration and					
scale					
	Materials Science: Specialisation Nano and F	lybrid Materials [,] Elective Compulsory			
-	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory				
i chowing curricula	Theoretical Mechanical Engineering: Special				

	Lecture	
	2	
СР	4	
Workload in Hours	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 metalli	
	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
Workload in Hours	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

C				
Courses				<u></u>
Title Methods in Theoretical Materials So	rianco (1.1677)	Typ Lecture	Hrs/wk	СР 4
Methods in Theoretical Materials S		Recitation Section (small)	1	2
Module Responsible	Prof. Stefan Müller			
Admission Requirements				
Recommended Previous	Knowledge of advanced mathematics like analysis, linear algebra, differential equations and complex functions, e.g., Mat			
Knowledge	I-IV			
	Knowledge of physics, particularly solid state	physics, e.g., Materials Physics		
Educational Objections				
Professional Competence	After taking part successfully, students have	reached the following learning results		
-	The master students will be able to			
	explain how different modeling methods we	ork.		
	assess the field of application of individual	methodological approaches.		
	evaluate the strengths and weaknesses of different methods.			
	The students are thereby able to assess wh	nich method is best suited to solve a scientif	ic problem and w	hat accuracy can
	expected from the simulation results.			
Skills	After completing the module, the students are able to			
	select the most suitable modeling method material type, etc	as a function of various parameters such as	length scale, time	e scale, temperatur
Personal Competence				
Social Competence		y and adapted to the target group with exper rences or exhibitions. Further, this promotes th		
	groups.			
Autonomy	The students are able to			
	assess their own strengths and weaknesses	5.		
	acquire the knowledge they need on their of	own.		
Workload in Hours Credit points		Lecture 42		
Credit points Course achievement				
Examination	Oral exam			
Examination duration and				
scale				
Assignment for the	Materials Science: Specialisation Modeling: El	lective Compulsory		
Following Curricula	Theoretical Mechanical Engineering: Specialis	sation Materials Science: Elective Compulsory		
	Theoretical Mechanical Engineering: Technica	al Complementary Course: Elective Compulsory	1	

Course L1677: Methods in Th	neoretical Materials Science
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Stefan Müller
Language	DE/EN
Cycle	SoSe
Content	1. Introduction
	1.1 Classification of Modelling Approaches and the Solid State
	2. Quantum Mechanical Approaches
	2.1 Electronic states : Atoms, Molecules, Solids
	2.2 Density Functional Theory
	2.3 Spin-Dynamics
	3. Thermodynamic Approaches
	3.1 Thermodynamic Potentials
	3.2 Alloys
	3.3 Cluster Expansion
	3.4 Monte-Carlo-Methods
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 Th	neoretical Materials Science
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	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

F itle Quantum Mechanics of Solids (L167! Quantum Mechanics of Solids (L167!	5)				
	5)		Тур	Hrs/wk	СР
uantum Mechanics of Solids (L167)			Lecture	2	4
	6)		Recitation Section (small)	1	2
Module Responsible	Prof. Stefan Müller				
Admission Requirements	None				
Recommended Previous Knowledge	Knowledge of advanced mathemation I-IV	cs like analysis, linear alg	gebra, differential equations and	complex functior	ns, e.g., Mathemati
	Knowledge of mechanics and physics, particularly solid state physics, e.g., Materials Physics				
Educational Objectives	After taking part successfully, stude	nts have reached the fol	lowing learning results		
Professional Competence					
Knowledge	The master students will be able to	explain			
	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 materials.				
	The master students will then be a atomistic scale in order to understa		materials properties in enginee	ring with materia	als properties on t
Skills	Skills After attending this lecture the students can				
	perform materials design on a qua	antum mechanical basis.			
Personal Competence					
	The students are able to discuss competently quantum-mechanics-based subjects with experts from fields such as physics an materials science.				
-	The students are able to independe they need to deal with more comple				quire the knowled
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42				
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and					
scale					
•	Materials Science: Specialisation Na				
-	Materials Science: Specialisation Mo		•		
	Theoretical Mechanical Engineering: Theoretical Mechanical Engineering:				

Course L1675: Quantum Mec	hanics of Solids	
Тур	Lecture	
Hrs/wk	2	
СР	4	
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28	
Lecturer	Prof. Stefan Müller	
Language	DE/EN	
Cycle		
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	
	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	
Literature	Physik für Ingenieure, Hering/Martin/Stohrer, Springer	
	Atom- und Quantenphysik, Haken/Wolf, Springer	
	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: Quantum Med	hanics of Solids
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	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 M1199: Adva				
Courses				
Title		Тур	Hrs/wk	СР
Advanced Functional Materials (L1	525)	Seminar	2	6
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous	Basic knowledge in Materials Science, e.g	. Materials Science I/II		
Knowledge				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	The students will be able to explain the p	properties of advanced materials along with	their applications in tech	nnology, in particu
	metallic, ceramic, polymeric, semiconduc	tor, modern composite materials (biomateria	als) and nanomaterials.	
Skills	The students will be able to select mat	erial configurations according to the techni	ical needs and, if neces	sarv. to design ne
Skins	s 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 or			
	modern materials science, which enables them to select optimum materials combinations depending on the to			
	applications.			
Personal Competence				
Social Competence	The students are able to present solutions	s to specialists and to develop ideas further.		
Autonomy	The students are able to			
	 assess their own strengths and weat 	akaossos		
	 gather new necessary expertise by 			
	• gutter new necessary expertise by	then own.		
Workload in Hours	Independent Study Time 152, Study Time	in Lecture 28		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Materials Science: Core qualification: Com	npulsory		
Following Curricula	Mechanical Engineering and Management	: Specialisation Materials: Elective Compulso	pry	
	• • •	tificial Organs and Regenerative Medicine: E		
		plants and Endoprostheses: Elective Compu	•	
		edical Technology and Control Theory: Electiv		
	• • •	anagement and Business Administration: Ele		
		nical Complementary Course: Elective Comp	-	
	Theoretical Mechanical Engineering: Spec	ialisation Materials Science: Elective Compu	lsory	

Course L1625: Advanced Fur	nctional Materials
Тур	Seminar
Hrs/wk	2
CP	6
Workload in Hours	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	1. Porous Solids - Preparation, Characterization and Functionalities
	2. Fluidics with nanoporous membranes
	3. Thermoplastic elastomers
	4. Optimization of polymer properties by nanoparticles
	5. Fiber composites in automotive
	6. Modeling of materials based on quantum mechanics
	7. Biomaterials
Literature	Aktuelle Publikationen aus der Fachliteratur werden während der Veranstaltung bekanntgegeben.

Courses				
		Tura	Line /unit	CD.
Title Materials Physics (L1624)		Typ Lecture	Hrs/wk	CP 2
Quantum Mechanics and Atomistic Materials Modeling (L1672)		Lecture	2	2
Exercises in Materials Physics and I	Aodeling (L2002)	Recitation Section (small)	2	2
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous	Advanced mathematics, physics and chemi	stry for students in engineering or natural science	ces	
Knowledge				
Educational Objectives	After taking part successfully, students hav	e reached the following learning results		
Professional Competence				
Knowledge	The students are able to			
	- explain the fundamentals of condensed m	atter physics		
				to the second second
	- describe the fundamentals of the microsco	opic structure and mechanics, thermodynamics	and optics of mater	lais systems.
	- to understand concept and realization or	f advanced methods in atomistic modeling as	well as to estimate	e their potential ar
	limitations.			
Skills	 After attending this lecture the students can perform calculations regarding the thermodynamics, mechanics, electrical and optical properties of condensed ma systems are able to transfer their knowledge to related technological and scientific fields, e.g. materials design problems. can select appropriate model descriptions for specific materials science problems and are able to further develop sin models. 			problems.
Personal Competence				
	The students are able to present solutions t	to specialists and to develop ideas further.		
Autonomy	Students are able to assess their knowldeg	e continuously on their own by exemplified pract	ice.	
	The students are able to assess their own s	trengths and weaknesses and define tasks indep	endently.	
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	90 min			
Assignment for the	Materials Science: Core qualification: Comp	ulsory		
Following Curricula		ical Complementary Course: Elective Compulsor	1	

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

	hanics and Atomistic Materials Modeling
	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Robert Meißner
Language	DE
Cycle	WiSe
Content	- Why atomistic materials modeling
	- Newton's equations of motion and numerical approaches
	- Ergodicity
	- Atomic models
	- Basics of quantum mechanics
	- Atomic & molecular many-electron systems
	- Hartree-Fock and Density-Functional Theory
	- Monte-Carlo Methods
	- Molecular Dynamics Simulations
	- Phase Field Simulations
Literature	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 M	faterials Physics and Modeling
Тур	Recitation Section (small)
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Robert Meißner, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	
Literature	- Daan Frenkel & Berend Smit: Understanding Molecular Simulation from Algorithms to Applications
	- Rudolf Gross und Achim Marx: Festkörperphysik
	- Neil Ashcroft and David Mermin: Solid State Physics

Module M1151: Mate	ials Modeling				
Courses					
Title		Тур	Hrs/wk	СР	
Material Modeling (L1535)		Lecture	2	3	
Material Modeling (L1536)		Recitation Section (small)	2	3	
Module Responsible	Prof. Christian Cyron				
Admission Requirements	None				
Recommended Previous	Basics of linear and nonlinear continuum mech	nanics as taught, e.g., in the modules Mechan	ics II and Continu	um Mechanics (for	
Knowledge	and moments, stress, linear and nonlinear stra	in, free-body principle, linear and nonlinear c	onstitutive laws, st	rain energy)	
Educational Objectives	After taking part successfully, students have re	eached the following learning results			
Professional Competence					
Knowledge	The students can explain the fundamentals of	multidimensional consitutive material laws			
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowledg				
	to various problems of material science and ev	valuate the corresponding material models.			
Personal Competence					
Social Competence	The students are able to develop solutions, to present them to specialists and to develop ideas further.				
Autonomy	The students are able to assess their own stre problems in the area of materials modeling an			wn identify and s	
	Independent Study Time 124, Study Time in Le	ecture 56			
Credit points					
Course achievement					
	Written exam				
Examination duration and	60 min				
scale					
-	Materials Science: Specialisation Modeling: Ele				
Following Curricula	Mechanical Engineering and Management: Spe				
	Biomedical Engineering: Specialisation Artificia		Compulsory		
	Biomedical Engineering: Specialisation Implant				
	Biomedical Engineering: Specialisation Medica				
	Biomedical Engineering: Specialisation Manage		Compulsory		
	Product Development, Materials and Productio				
	Theoretical Mechanical Engineering: Specialisa				
	Theoretical Mechanical Engineering: Specialisa	tion Simulation Technology: Elective Compute	sory		

Course L1535: Material Mode	eling
Тур	Lecture
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	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	

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Course L1536: Material Mode	eling
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

Courses				
Title		Тур	Hrs/wk	СР
Experimental Methods for the Char		Lecture	2	3
Phase equilibria and transformation		Lecture	2	3
Module Responsible	Prof. Jörg Weißmüller			
Admission Requirements	None			
Recommended Previous	Basic knowledge in Materials Science, e.g. V	/erkstoffwissenschaft I/II		
Knowledge				
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
Knowledge	The students will be able to explain the pro	perties of advanced materials along with	their applications in tech	nnology, in particul
	metallic, ceramic, polymeric, semiconductor	, modern composite materials (biomateri	als) and nanomaterials.	
Chille	The students will be able to select materi	al configurations according to the tech	ical needs and if neces	sary to decign no
JKIIIS	Skills The students will be able to select material configurations according to the technical needs and, if necessary, to materials considering architectural principles from the micro- to the macroscale. The students will also gain an c modern materials science, which enables them to select optimum materials combinations depending on the			
	applications.			
	applications.			
Personal Competence				
Social Competence	The students are able to present solutions to	specialists and to develop ideas further		
Autonomy	The students are able to			
	- access their own strengths and weak			
	assess their own strengths and weak			
	 gather new necessary expertise by the 	en own.		
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering:	Specialisation II. Product Development a	nd Production: Elective Co	ompulsory
Following Curricula	Materials Science: Core qualification: Compu			
-	Product Development, Materials and Produc		: Elective Compulsory	
	Product Development, Materials and Produc	tion: Specialisation Production: Elective C	Compulsory	
	Product Development, Materials and Produc	tion: Specialisation Materials: Compulsory	/	
	Theoretical Mechanical Engineering: Technic	al Complementary Course: Elective Com	pulsory	
	Theoretical Mechanical Engineering: Special	isation Materials Science: Elective Comp	ilsorv	

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	 Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
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 equilib	ria and transformations
	Lecture
Hrs/wk	
СР	3
Workload in Hours	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.

oursos						
Courses						
Title				Тур	Hrs/wk	СР
Product Planning (L0851) Product Planning Seminar (L0853)				Lecture Project-/problem-based Learning	3 2	3 3
	Prof. Cornelius Herstatt			Troject-problem-based Learning	2	5
	None					
Admission Requirements		6 Dunin and Administration				
Recommended Previous Knowledge	Good basic-knowledge o	or Business Administrat	lon			
	After taking part success	sfully, students have r	ached the followin	a learning results		
	Arter taking part success	siully, students nave re		ig learning results		
Professional Competence Knowledge	Students will gain insigh	nts into:				
	Product Planning					
	 Process 					
	 Methods 					
	 Design thinking 					
	 Process 					
	 Methods 					
	 User integr 	ation				
Skills	Students will gain deep i	insights into:				
	Product Planning					
	 Process-rel 	ated aspects				
		onal-related aspects				
		ssource related aspect	S			
		ols, methods and instr				
	0					
Personal Competence						
Social Competence						
Social competence	 Interact within a t 	eam				
	 Raise awareness f 	for globabl issues				
Autonomy						
, aconomy	 Gain access to kn 	owledge sources				
	 Interpret complex 	cases				
	 Develop presenta 	tion skills				
Workload in Hours	Independent Study Time	e 110, Study Time in Le	ecture 70			
Credit points	6					
Course achievement		orm	Description			
		Subject theoretical	and			
		oractical work				
	Written exam					
Examination duration and scale	90 minutes					
Assignment for the	Global Innovation Manag	gement: Core qualifica	tion: Compulsory			
Following Curricula	International Manageme	ent and Engineering: S	pecialisation I. Elec	tives Management: Elective Cor	npulsory	
	Mechanical Engineering	and Management: Spe	cialisation Manage	ement: Elective Compulsory		
	Product Development, M	laterials and Productio	n: Specialisation Pr	roduct Development: Elective Co	ompulsory	
	Product Development, M	laterials and Productio	n: Specialisation Pr	roduction: Elective Compulsory		
	Product Development, M	laterials and Productio	n: Specialisation M	laterials: Elective Compulsory		
	Theoretical Mechanical E	Engineering: Specialisa	tion Product Devel	lopment and Production: Elective	e Compulsory	
	Theoretical Mechanical E	- Engineering: Technical	Complementary C	ourse: Elective Compulsory		

Lecturer Prof. Corneliu Language EN Cycle WiSe Content Product Plann This integrate key activity for Systemat Understan Exploring Developin creating a sti Transferri Voluntary pre	
Workload in Hours Independent Lecturer Prof. Corneliu Language EN Cycle WiSe Content Product Plan This integrate key activity fr Systemat Understai Exploring Developin creating a sti Transferri Voluntary pre Voluntary pre	is Herstatt hing Process ed lecture is designed to understand major issues, activities and tools in the context of systematic product planning, a or managing the front-end of innovation, i.e.: ic scanning of markets for innovation opportunities nding strengths/weakness and specific core competences of a firm as platforms for innovation relevant sources for innovation (customers, suppliers, Lead Users, etc.) ng ideas for radical innovation, relying on the creativeness of employees, using techniques to stimulate creativity and
Lecturer Prof. Corneliu Language EN Cycle WiSe Content Product Plann This integrate key activity for Systemat Understan Exploring Developin creating a sti Transferri Voluntary pre	is Herstatt hing Process ed lecture is designed to understand major issues, activities and tools in the context of systematic product planning, a or managing the front-end of innovation, i.e.: ic scanning of markets for innovation opportunities nding strengths/weakness and specific core competences of a firm as platforms for innovation relevant sources for innovation (customers, suppliers, Lead Users, etc.) ng ideas for radical innovation, relying on the creativeness of employees, using techniques to stimulate creativity and
Language EN Cycle WiSe Content Product Plann This integrate key activity fr Systemat Understan Exploring Developin creating a sti Transferri Voluntary pre Voluntary pre	ning Process ed lecture is designed to understand major issues, activities and tools in the context of systematic product planning, a or managing the front-end of innovation, i.e.: ic scanning of markets for innovation opportunities nding strengths/weakness and specific core competences of a firm as platforms for innovation relevant sources for innovation (customers, suppliers, Lead Users, etc.) ng ideas for radical innovation, relying on the creativeness of employees, using techniques to stimulate creativity and
Cycle WiSe Content Product Plan This integrate key activity fr • Systemat • Understan • Exploring • Developin creating a sti • Transferri Voluntary pre	ed lecture is designed to understand major issues, activities and tools in the context of systematic product planning, a or managing the front-end of innovation, i.e.: ic scanning of markets for innovation opportunities nding strengths/weakness and specific core competences of a firm as platforms for innovation relevant sources for innovation (customers, suppliers, Lead Users, etc.) ng ideas for radical innovation, relying on the creativeness of employees, using techniques to stimulate creativity and
Content Product Plan This integrate key activity fr Systemat Understar Exploring Developin creating a sti Transferri Voluntary pre	ed lecture is designed to understand major issues, activities and tools in the context of systematic product planning, a or managing the front-end of innovation, i.e.: ic scanning of markets for innovation opportunities nding strengths/weakness and specific core competences of a firm as platforms for innovation relevant sources for innovation (customers, suppliers, Lead Users, etc.) ng ideas for radical innovation, relying on the creativeness of employees, using techniques to stimulate creativity and
This integrate key activity fr • Systemat • Understar • Exploring • Developin creating a sti • Transferri Voluntary pre	ed lecture is designed to understand major issues, activities and tools in the context of systematic product planning, a or managing the front-end of innovation, i.e.: ic scanning of markets for innovation opportunities nding strengths/weakness and specific core competences of a firm as platforms for innovation relevant sources for innovation (customers, suppliers, Lead Users, etc.) ng ideas for radical innovation, relying on the creativeness of employees, using techniques to stimulate creativity and
key activity fr Systemat Understar Exploring Developin creating a sti Transferri Voluntary pre	or managing the front-end of innovation, i.e.: ic scanning of markets for innovation opportunities nding strengths/weakness and specific core competences of a firm as platforms for innovation relevant sources for innovation (customers, suppliers, Lead Users, etc.) ng ideas for radical innovation, relying on the creativeness of employees, using techniques to stimulate creativity and
- Permanent Examination: In addition to groups in ord	ing ideas for innovation into feasible concepts which have a high market attractively esentations in the third hour (articles / case studies) res by researchers Sustainability with frequent reference to current research reference to current research

Course L0853: Product Plann	ning Seminar
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	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".

Courses				
Title		Typ	Hrs/wk	СР
The Digital Enterprise (L0932)		Typ Lecture	2	2
Production Planning and Control (L	1929)	Lecture	2	2
Production Planning and Control (L		Recitation Section (small)	1	1
Exercise: The Digital Enterprise (L0933)		Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous	Fundamentals of Production and Quality	/ Management		
Knowledge				
Educational Objectives	After taking part successfully, students	have reached the following learning 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 a	pplying models and methods from the module to indu	strial problems.	
Personal Competence				
Social Competence	Students can develop joint solutions in r	mixed teams and present them to others.		
Autonomy	-			
Workload in Hours	Independent Study Time 96, Study Time	e in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 Minuten			
scale				
Assignment for the	International Management and Engineer	ring: Specialisation II. Product Development and Prod	uction: Elective C	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
	Biomedical Engineering: Specialisation I	ical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			
	Biomedical Engineering: Specialisation Management and Business Administration: Compulsory			
	Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory			
	Product Development, Materials and Pro	oduction: Specialisation Production: Compulsory		
	Product Development, Materials and Pro	oduction: Specialisation Materials: Elective Compulsor	У	
	Theoretical Mechanical Engineering: Spe	ecialisation Product Development and Production: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Teo	chnical Complementary Course: Elective Compulsory		

Course L0932: The Digital Er	Iterprise
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	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 Pla	anning and Control
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hermann Lödding
Language	DE
Cycle	WiSe
Content	 Models of Production and Inventory Management Production Programme Planning and Lot Sizing Order and Capacity Scheduling Selected Strategies of PPC Manufacturing Control Production Controlling Supply Chain Management
Literature	 Vorlesungsskript Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008 Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002

Course L0930: Production Pl	anning and Control
Тур	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	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
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	Siehe korrespondierende Vorlesung
	See interlocking course

urses				
itle		Тур	Hrs/wk	СР
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous	see FSPO			
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	see FSPO			
Autonomy	see FSPO			
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the	Theoretical Mechanical Engineering: Specialis	ation Product Development and Produc	tion: Elective Compulsory	
Following Curricula	Theoretical Mechanical Engineering: Specialis	ation Aircraft Systems Engineering: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Specialis	ation Materials Science: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Specialis	ation Maritime Technology: Elective Co	mpulsory	
	Theoretical Mechanical Engineering: Specialis	ation Energy Systems: Elective Compu	lsory	
	Theoretical Mechanical Engineering: Specialis	ation Bio- and Medical Technology: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Specialis	ation Robotics and Computer Science:	Elective Compulsory	
	Theoretical Mechanical Engineering: Specialis	ation Simulation Technology: Elective (Compulsory	

Courses				
Title		Тур	Hrs/wk	СР
Integrated Product Development II	(L1254)	Lecture	3	3
Integrated Product Development II	(L1255)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Dieter Krause			
Admission Requirements	None			
Recommended Previous	Basic knowledge of Integrated product development and apply	ring CAE systems		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follow	wing learning results		
Professional Competence				
Knowledge	After passing the module students are able to:			
	• explain technical terms of design methodology,			
	 describe essential elements of construction management 	at		
	 describe current problems and the current state of rese 		ment.	
	···· · · · · · · · · · · · · · · · · ·			
Skills	After passing the module students are able to:			
	 select and apply proper construction methods for non- 	standardized solutions of problem	ns as well as	adapt new bounda
	conditions,	· · · · · · · · · · · · · · · · · ·		
	 solve product development problems with the assistance of a workshop based application. 			
	choose and execute appropriate moderation techniques			
Personal Competence				
Social Competence	After passing the module students are able to:			
	prepare and lead team meetings and moderation proces	sses,		
	 work in teams on complex tasks, 			
	 represent problems and solutions and advance ideas. 			
Autonomy	After passing the module students are able to:			
Autonomy	Arter passing the module students are able to.			
	 give a structured feedback and accept a critical feedback 	sk,		
	 implement the accepted feedback autonomous. 			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points				
Course achievement				
Examination				
Examination duration and				
scale				
	Aircraft Systems Engineering: Specialisation Cabin Systems: El	ective Compulsory		
Following Curricula		1 5		
	Aircraft Systems Engineering: Core qualification: Elective Com			
	International Management and Engineering: Specialisation II. F		on: Elective C	ompulsory
	Mechatronics: Specialisation System Design: Elective Compuls			
	Product Development, Materials and Production: Specialisation	Product Development: Compulsor	У	
	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 De	velopment and Production: Elective	e Compulsory	

rse L1254: Integrated Pro	· · · · · · · · · · · · · · · · · · ·
	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	WiSe
Content	
	The lecture extends and enhances the learned content of the module "Integrated Product Development and lightweight desig 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
	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 a design management will be enhanced.
	Students learn an independently moderated and workshop based approach through industry related practice examples to so complex and currently existing issues in product development. They will learn the ability to apply important methods of prod 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 workshop based structure of the event under its own planning and management.
Literature	Andreasen, M.M., Design for Assembly, Berlin, Springer 1985.
	 Andreaser, M.M., Design for Asserbicty, Definit, opringer 1903. Ashby, M. F.: Materials Selection in Mechanical Design, München, Spektrum 2007. Beckmann, H.: Supply Chain Management, Berlin, Springer 2004. Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater u Trainer, Weinheim, Beltz 2007. Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006. Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000. Simpson, T.W., Siddique, Z., Jiao, R.J.: Product Platform and Product Family Design. Methods and Applications, New Yo
	 Trainer, Weinheim, Beltz 2007. Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006. Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000.

Course L1255: Integrated Pr	ourse L1255: Integrated Product Development II	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
Workload in Hours	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		Тур	Hrs/wk	СР	
Applied Design Methodology in Me	chatronics (L1523)	Lecture	2	2	
Applied Design Methodology in Me	chatronics (L1524)	Project-/problem-based Learnin	g 3	4	
Module Responsible	Prof. Thorsten Kern				
Admission Requirements	None				
Recommended Previous	Basics of mechanical design, electrical design	n or computer-sciences			
Knowledge					
Educational Objectives	After taking part successfully, students have	e reached the following learning results			
Professional Competence					
Knowledge	Science-based working on interdisciplinary p	roduct design considering targeted application of	specific product	design technique	
Skille					
SKIIIS	creative handling of processes used for scientific preparation and formulation of complex product design problems / Application various product design techniques following theoretical aspects.				
	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 app			s with applicatio	
	common, creative methodologies.				
Autonomy	Students are enabled to optimize the design	and development process according to the target	and topic of the	e design	
Workload in Hours	Independent Study Time 110, Study Time in	Lecture 70			
Credit points	6				
Course achievement	None				
Examination	Subject theoretical and practical work				
Examination duration and	30 min Presentation for a group design-work				
scale					
Assignment for the	International Management and Engineering:	Specialisation II. Product Development and Produc	tion: Elective C	ompulsory	
Following Curricula	International Management and Engineering:	Specialisation II. Mechatronics: Elective Compulso	ry		
	Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory				
	Mechatronics: Specialisation System Design: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
		ants and Endoprostheses: Elective Compulsory			
		cal Technology and Control Theory: Elective Comp	-		
		agement and Business Administration: Elective Cor			
		isation Product Development and Production: Elect	ive Compulsory		
	Theoretical Mechanical Engineering: Technic	al Complementary Course: Elective Compulsory			

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

Course L1524: Applied Desig	In 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

Courses					
Title		Тур	Hrs/wk	СР	
Advanced Topics in Vibration (L174	3)	Project-/problem-based Learning	4	6	
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous	Vibration Theory				
Knowledge					
Educational Objectives	After taking part successfully, students have reached the	e following learning results			
Professional Competence					
Knowledge	Students are able to reflect existing terms and concepts of Ac	vanced Vibrations and to develop and resea	arch new terms	and concepts.	
Skills	Students are able to apply existing methods and procesures of	f Advanced Vibrations and to develop novel	methods and p	procedures.	
Personal Competence					
Social Competence	Students can reach working results also in groups.				
Autonomy	Students are able to approach given research tasks individua	ly and to identify and follow up novel resear	ch tasks by the	mselves.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	2 Hours				
scale					
Assignment for the	Mechatronics: Specialisation System Design: Elective Co	mpulsory			
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Rol	otics: Elective Compulsory			
	Mechatronics: Technical Complementary Course: Elective Compulsory				
	Theoretical Mechanical Engineering: Technical Complem	entary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Produ	ct Development and Production: Elective	e Compulsory		

Course L1743: Advanced Top	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 M0805: Tech	ical Acoustics I (Acoustic Waves, No	ise Protection, Psycho Aco	ustics)	
Courses				
Title		Тур	Hrs/wk	СР
Technical Acoustics I (Acoustic Wa	es, Noise Protection, Psycho Acoustics) (L0516)	Lecture	2	3
Technical Acoustics I (Acoustic Way	es, Noise Protection, Psycho Acoustics) (L0518)	Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and Mec	hanics II (Hydrostatics, Kinematics, Dyn	amics)	
Knowledge	Mathematics I, 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 an in-depth knowledge in acou	stics regarding acoustic waves, noise	protection, and p	sycho acoustics a
	are able to give an overview of the corresponding the	oretical and methodical basis.		
<i></i>				
SKIIIS	The students are capable to handle engineering		ased application	of the demand
	methodologies and measurement procedures treated	within the module.		
Personal Competence				
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.			
Autonomy	The students are able to independently solve shalls	naing acquistical problems in the areas	s tracted within	the module Bessit
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possib conflicting issues and limitations can be identified and the results are critically scrutinized.			
	conneting issues and innitiations can be identified and	The results are endeally selutinized.		
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	90 min			
scale				
Assignment for the	Energy Systems: Core qualification: Elective Compulse	pry		
Following Curricula	Aircraft Systems Engineering: Core qualification: Elect	ive Compulsory		
	International Management and Engineering: Specialisa	ation II. Aviation Systems: Elective Com	pulsory	
	Mechatronics: Specialisation System Design: Elective	Compulsory		
	Product Development, Materials and Production: Core	qualification: Elective Compulsory		
	Technomathematics: Specialisation III. Engineering Sc	ience: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Comple			
	Theoretical Mechanical Engineering: Specialisation Pro	oduct Development and Production: Elec	ctive Compulsory	

Course L0516: Technical Aco	Course L0516: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Otto von Estorff		
Language	EN		
Cycle	SoSe		
Content	- Introduction and Motivation		
	- Acoustic quantities		
	- Acoustic waves		
	- Sound sources, sound radiation		
	- Sound engergy and intensity		
	- Sound propagation		
	- Signal processing		
	- Psycho acoustics		
	- Noise		
	- Measurements in acoustics		
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 Aco	rse L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	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		

Courses				
Title		Тур	Hrs/wk	СР
Automation Technology and Systems (L2329)		Lecture	4	4
Automation Technology and Systems (L2331) Automation Technology and Systems (L2330)		Project-/problem-based Learning Recitation Section (small)	1 1	1 1
	Prof. Thorsten Schüppstuhl	Recitation Section (small)	1	1
Admission Requirements				
	without major course assessment			
Kecommended Previous				
5	After taking part successfully, students have reached t	a following learning results		
Professional Competence	After taking part successfully, students have reached t			
Knowledge	Students			
hitemedge				
	 know the characteristic components of an auton 		ing of their in	teraction
	 know methods for a systematical analysis of aut 			
	 have special competences in industrial robot bas 	ed automation systems		
Skills	Students are able to			
	analyze complex Automation tasks			
	develop application based concepts and solutions			
	 design subsystems and integrate into one system investigate and evaluate cafety of mashingry 			
	 investigate and evaluate safety of machinery create simple programs for robots and programmable logic controllers 			
	 design of circuit for pneumatic applications 			
	• design of circuit for pricultatic applications			
Personal Competence				
Social Competence	Students are able to			
	- find solutions for automation and handling tasks in gr	auc		
	- develop solutions in a production environment with c	ualified personnel at technical level and re	epresent decis	sions.
Autonomy	Students are able to			
	analyze automation tasks independently			
	generate programs for robots and programmable logic devices autonomously			
	 develop solutions for practice oriented tasks of automation independently design safety consents for automation applications 			
	 design safety concepts for automation applications assess consequences of their professional actions and responsibilities 			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	International Management and Engineering: Specialisa	ion II. Product Development and Production	on: Elective Co	ompulsory
Following Curricula	Product Development, Materials and Production: Specia		ompulsory	
	Product Development, Materials and Production: Specia			
	Product Development, Materials and Production: Specia			
	Theoretical Mechanical Engineering: Technical Comple			
	Theoretical Mechanical Engineering: Specialisation Pro-	luct Development and Production: Elective	e Compulsory	

Course L2329: Automation T	echnology 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 T	urse 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 T	Course L2330: Automation Technology and Systems	
Тур	Recitation Section (small)	
Hrs/wk	1	
CP	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	

Courses				
Title		Тур	Hrs/wk	СР
Laser Systems and Process Technologies (L1612)		Lecture	2	3
Methods for Analysing Production I	Processes (L0876)	Lecture	2	3
Module Responsible	Prof. Wolfgang Hintze			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, student	s have reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study T	ime in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	Product Development, Materials and F	Production: Specialisation Product Development: I	Elective Compulsory	
Following Curricula	Product Development, Materials and F	Production: Specialisation Production: Compulsory	/	
	Product Development, Materials and F	Production: Specialisation Materials: Elective Com	pulsory	
	Theoretical Mechanical Engineering: S	pecialisation Product Development and Production	on: Elective Compulsory	,
	Theoretical Mechanical Engineering: 1	echnical Complementary Course: Elective Compu	ulsory	

Course L1612: Laser Systems	s and Process Technologies		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	ependent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Claus Emmelmann		
Language	EN		
Cycle	WiSe		
Content	 Fundamentals of laser technology Laser beam sources: CO2-, Nd:YAG-, Fiber- and Diodelasers Laser system technology: beam forming, beam guidance systems, beam motion and beam control Laser-based manufacturing technologies: generation, marking, cutting, joining, surface treatment Quality assurance and economical aspects of laser material processing Markets and Applications of laser technology Student group exercises 		
Literature	 Hügel, H., T. Graf: Laser in der Fertigung : Strahlquellen, Systeme, Fertigungsverfahren, 3. Aufl., Vieweg + Teubner Wiesbaden 2014. Eichler, J., Eichler. H. J.: Laser: Bauformen, Strahlführung, Anwendungen, 7. Aufl., Springer-Verlag Berlin Heidelberg 2010. Steen W. M.; Mazumder J.: Laser material processing, 4th Edition, Springer-Verlag London 2010. J.C. Ion: Laser processing of engineering materials: principles, procedure and industrial applications, Elsevier Butterworth-Heinemann 2005. Gebhardt, A.: Understanding additive manufacturing, München [u.a.] Hanser 2011 		

Course L0876: Methods for A	Analysing Production Processes
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Wolfgang Hintze
Language	DE
Cycle	WiSe
Content	 Modelling and simulation of maching and forming processes Numerical simulation of forces, temperatures, deformation in machining Analysis of vibration problems in maching (chatter, modal analysis,) Knowledge based process planning Design of experiments Machinability of nonmetallic materials Analysis of interaction between maching process and machine tool systems with regard to process stability and quality Simulation of maching processes by virtual reality methods
	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					
Title		Тур	Hrs/wk	СР	
Technical Acoustics II (Room Acoustics, Computational Methods) (L0519)		Lecture	2	3	
	tics, Computational Methods) (L0521)	Recitation Section (large)	2	3	
Module Responsible					
Admission Requirements	None				
	Technical Acoustics I (Acoustic Waves, Noise Prote	ection, Psycho Acoustics)			
Knowledge	Mechanics I (Statics, Mechanics of Materials) and	Mechanics II (Hydrostatics, Kinematics, Dyn	amics)		
	Mathematics I, II, III (in particular differential equations)				
Educational Objectives	After taking part successfully, students have reac	hed the following learning results			
Professional Competence					
Knowledge	The students possess an in-depth knowledge in acoustics regarding room acoustics and computational methods and are able				
	give an overview of the corresponding theoretical and methodical basis.				
<i>CL 11</i>					
SKIIIS	s The students are capable to handle engineering problems in acoustics by theory-based application of the demandi computational methods and procedures treated within the module.				
	computational methods and procedures treated w	inn ne module.			
Personal Competence					
Social Competence	Students can work in small groups on specific pro	blems to arrive at joint solutions.			
Autonomy	The students are able to independently solve sh	allonging acoustical problems in the area	s tracted within	the module Doce	
Autonomy	r The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possil conflicting issues and limitations can be identified and the results are critically scrutinized.				
		and the results are endeally selatimized.			
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ure 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	20-30 Minuten				
scale					
Assignment for the	Aircraft Systems Engineering: Core qualification: I	Elective Compulsory			
Following Curricula	Aircraft Systems Engineering: Specialisation Cabin	n Systems: Elective Compulsory			
	Mechatronics: Specialisation System Design: Elect				
	Product Development, Materials and Production: (
	Theoretical Mechanical Engineering: Technical Co				
	Theoretical Mechanical Engineering: Specialisation	n Product Development and Production: Ele	ctive Compulsory	r	

Course L0519: Technical Acoustics II (Room Acoustics, Computational Methods)		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	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 Aco	ourse L0521: Technical Acoustics II (Room Acoustics, Computational Methods)		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	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		

Courses				
Courses		T	Line fords	<u></u>
Title Factory Planning (L1445)		Typ Lecture	Hrs/wk 3	СР 3
Production Logistics (L1446)		Lecture	2	3
Module Responsible	Prof. Jochen Kreutzfeldt			
Admission Requirements	None			
Recommended Previous	Bachelor degree in logistics			
Knowledge				
Educational Objectives	After taking part successfully, students have read	hed the following learning results		
Professional Competence				
Knowledge	The students will acquire the following knowledge	2:		
	1. The students know the latest trends and devel	opments in the planning of factories		
	 The students can explain basic procedures of different conditions. 	of factory planning and are able to	o deploy these procedure	es while consideri
	3. The students know different methods of factor	y planning and are able to deal critic	cally with these methods.	
Skills	The students will acquire the following skills:			
Skills	1. The students are able to analyze factories and	d other material flow systems with	regard to new developme	ent and the need
	change of these logistical systems.			
	2. The students are able to plan and redesign fac			
	3. The students are able to develop procedures for	or the implementation of new and re	evised material flow syster	ns.
Personal Competence				
Social Competence	The students will acquire the following social skill 1. The students are able to develop plans for the group.		nent of existing material fl	ow systems withir
	2. The developed planning proposal from the grou	up work can be documented and pre	esented together.	
	The students are able to derive suggestions for constructive criticism themselves.	r improvement from the feedback or	n the planning proposals a	nd can even prov
Autonomv	The students will acquire the following independe	ent competencies:		
	1. The students can plan and re-design material f		procedures.	
	 The students can evaluate independently the appropriate methods in a given context. 	strengths and weaknesses of sever	al techniques for factory p	planning and choo
	3. The students are able to carry out autonomous	sly new plans and transformations of	f material flow systems.	
Workload in Hours	Independent Study Time 110, Study Time in Lect	ure 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
•	International Management and Engineering: Spec			ompulsory
Following Curricula	International Management and Engineering: Spec Logistics, Infrastructure and Mobility: Specialisati			
	Theoretical Mechanical Engineering: Technical Co			
	Theoretical Mechanical Engineering: Specialisatio			

urse L1445: Factory Plann	ing
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
Content	 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 (3) Implementation and realization of factory planning
	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.
Literature	 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. 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: Production Lo	gistics
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	DiplIng. Arnd Schirrmann
Language	DE
Cycle	WiSe
Content	 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 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) Logistics-compatible production and process structuring; logistics-compatible product, material flow, information and organizational structures Logistics-oriented production control: situation and development tendencies, logistics and cybernetics, market-oriented production logistics control systems. Production logistics planning: key performance indicators, developing a production logistics concept, computerized aids to planning production logistics, IPPL functions, economic efficiency of logistics projects 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)
Literature	Pawellek, G.: Produktionslogistik: Planung - Steuerung - Controlling. Carl Hanser Verlag 2007

Courses				
Title		Тур	Hrs/wk	СР
Fluidics (L1256)		Lecture	2	3
Fluidics (L1371)		Project-/problem-based Learning	1	2
Fluidics (L1257)		Recitation Section (large)	1	1
Module Responsible				
Admission Requirements				
	Good knowledge of mechanics (stereo statics, elastostatics	, hydrostatics, kinematics and	kinetics), fluid	mechanics, a
Knowledge	engineering design			
Educational Objectives	After taking part successfully, students have reached the followi	ng learning results		
Professional Competence				
Knowledge	After passing the module students are able to			
	explain structures and functionalities of hydrostatic, pneu		nents,	
	explain the interaction of hydraulic components in hydrau			
	explain open and closed loop control of hydraulic systems			
	 describe functioning and applications of hydrodynamic to and aggregates in plant technology. 	inque converters, brakes and clut	ches as well as	centrifugai pun
	and aggregates in plant technology			
Skills	After passing the module students are able to			
	 analyse and assess hydraulic and pneumatic components 	and systems		
	 design and dimension hydraulic systems for mechanical a 			
	 perform numerical simulations of hydraulic systems based 			
	 select and adapt pump characteristic curves for hydraulic 		,	
	 dimension hydrodynamic torgue converters and brakes for 			
Personal Competence				
Social Competence	After passing the module students are able to			
	 discuss and present functional context in groups, 			
	 organise teamwork autonomously. 			
Autonomy	After passing the module students are able to			
	 obtain necessary knowledge for the simulation. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Description			
	Yes None Attestation Simulation hy	ydrostatischer Systeme		
Examination	Written exam			
Examination duration and	90			
scale				
Assignment for the	International Management and Engineering: Specialisation II. Me	chatronics: Elective Compulsory		
Following Curricula				
	Product Development, Materials and Production: Specialisation P	Product Development: Compulsor	У	
	Product Development, Materials and Production: Specialisation P	Production: Elective Compulsory		
	Product Development, Materials and Production: Specialisation N			
	Theoretical Mechanical Engineering: Technical Complementary C			
	Theoretical Mechanical Engineering: Specialisation Product Deve	elopment and Production: Elective	e Compulsory	

Course L1256: Fluidics		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Dieter Krause	
Language	DE	
Cycle	WiSe	
Content	Lecture	
	Hydrostatics physical fundamentals hydraulic fluids hydrostatic machines 	
	valves	
	components	
	hydrostatic transmissions	
	examples from industry	
	Pneumatics	
	generation of compressed air	
	pneumatic motors	
	Examples of use	
	Hydrodynamics	
	physical fundamentals	
	hydraulic continous-flow machines	
	hydrodynamic transmissions interpreting of mater and transmission	
	interoperation of motor and transmission	
	Exercise	
	Hydrostatics	
	 reading and design of hydraulic diagrams dimensioning of hydrostatic traction and working drives performance calculation 	
	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 	
Literature	Bücher	
	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, KH.: Dubbel - Taschenbuch für den Maschinenbau, Springer-Verlag, Berlin, aktuelle Auflage	
	Skript zur Vorlesung	

Course L1371: Fluidics	ourse L1371: Fluidics		
Тур	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	ourse L1257: Fluidics	
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	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 M0563: Robo				
Courses				
Title	Ту	γp	Hrs/wk	СР
Robotics: Modelling and Control (LC	-	egrated Lecture	4	4
Robotics: Modelling and Control (L1		oject-/problem-based Learning	2	2
Module Responsible				
Admission Requirements				
Recommended Previous	Fundamentals of electrical engineering			
Knowledge	Broad knowledge of mechanics			
	Fundamentals of control theory			
Educational Objectives	After taking part successfully, students have reached the following lo	earning results		
Professional Competence				
Knowledge	Students are able to describe fundamental properties of robots and	solution approaches for multi	ple problems ir	n robotics.
Skills	Students are able to derive and solve equations of motion for variou	ıs manipulators.		
	Students can generate trajectories in various coordinate systems.			
	Students can design linear and partially nonlinear controllers for rob	ootic manipulators.		
Personal Competence				
Social Competence	Students are able to work goal-oriented in small mixed groups.			
Autonomy	Students are able to recognize and improve knowledge deficits inde	pendently.		
	With instructor assistance, students are able to evaluate their own k	nowledge level and define a	further course o	of study.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Aircraft Systems Engineering: Core qualification: Elective Compulsor	ry		
Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Election	ve Compulsory		
	International Management and Engineering: Specialisation II. Mecha	tronics: Elective Compulsory		
	International Management and Engineering: Specialisation II. Produc		on: Elective Con	npulsory
	Mechanical Engineering and Management: Core qualification: Compu	ulsory		
	Mechatronics: Core qualification: Compulsory			
	Product Development, Materials and Production: Specialisation Produ		mpulsory	
	Product Development, Materials and Production: Specialisation Produ			
	Product Development, Materials and Production: Specialisation Mate			
	Theoretical Mechanical Engineering: Technical Complementary Cour		nulcon	
	Theoretical Mechanical Engineering: Specialisation Robotics and Cor	inputer science: Elective Com	puisory	

Course L0168: Robotics: Mod	lelling and Control
Тур	Integrated Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Dr. Martin Gomse
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: Mod	rse L1305: Robotics: Modelling and Control	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Dr. Martin Gomse	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses				
Title		Тур	Hrs/wk	СР
Mathematics of Neural Networks (L	2322)	Lecture	2	3
Mathematics of Neural Networks (L	2323)	Recitation Section (small)	2	3
Module Responsible	Dr. Jens-Peter Zemke			
Admission Requirements	None			
Recommended Previous	7 Martha and 19 and 19			
Knowledge	1. Mathematics I-III			
	2. Numerical Mathematics 1/ Numerics			
	3. Programming skills, preferably in Pytho	3h		
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	Students are able to name, state and classify	y state-of-the-art neural networks and their corre	esponding mathe	matical basics. Th
	can assess the difficulties of different neural r	networks.		
Skills	Students are able to implement, understand,	and, tailored to the field of application, apply ne	ural networks.	
Personal Competence				
Social Competence				
	develop and document joint solutions i			
	• •	as and transfer them to other areas of applicabil	ity;	
	 form a team to develop, build, and adv 	ance a software library.		
Autonomy	Students are able to			
	 correctly assess the time and effort of 	self defined work		
	,	ical and practical excercises are better solved in	dividually or in a	team
	 define test problems for testing and ex 			teann,
		necessary, to ask questions and seek help.		
		recessury, to usk questions and seek help.		
Workload in Hours	Independent Study Time 124, Study Time in L	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	25 min			
scale				
Assignment for the	Computer Science: Specialisation III. Mathema	atics: Elective Compulsory		
Following Curricula	Computational Science and Engineering: Spec	cialisation III. Mathematics: Elective Compulsory		
	Mechatronics: Specialisation Intelligent System	ms and Robotics: Elective Compulsory		
	Mechatronics: Technical Complementary Cou	rse: Elective Compulsory		
	Technomathematics: Specialisation I. Mathem	natics: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialis	ation Robotics and Computer Science: Elective O	Compulsory	

Course L2322: Mathematics of Neural Networks		
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	1. Basics: analogy; layout of neural nets, universal approximation, NP-completeness	
	 Pasies: analogy, layout of neural nets, universal approximation, we completeness Feedforward nets: backpropagation, variants of Stochastistic Gradients 	
	3. Deep Learning: problems and solution strategies	
	4. Deep Belief Networks: energy based models, Contrastive Divergence	
	5. CNN: idea, layout, FFT and Winograds algorithms, implementation details	
	6. RNN: idea, dynamical systems, training, LSTM	
	7. ResNN: idea, relation to neural ODEs	
	8. Standard libraries: Tensorflow, Keras, PyTorch	
	9. Recent trends	
Literature		
	1. Skript	
	2. Online-Werke:	
	http://neuralnetworksanddeeplearning.com/ http://www.dooplearning.com/	
	 https://www.deeplearningbook.org/ 	

Course L2323: Mathematics	urse L2323: Mathematics of Neural Networks	
Тур	Recitation Section (small)	
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	See interlocking course	
Literature	See interlocking course	

Courses		
Title	Tup Her/uk CD	
Digital Image Analysis (L0126)	Typ Hrs/wk CP Lecture 4 6	
	Prof. Rolf-Rainer Grigat	
Admission Requirements		
	System theory of one-dimensional signals (convolution and correlation, sampling theory, interpolation and decimation	Fouri
	transform, linear time-invariant systems), linear algebra (Eigenvalue decomposition, SVD), basic stochastics and (expectation values, influence of sample size, correlation and covariance, normal distribution and its parameters), basics of basics in optics	statisti
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	Students can	
	Describe imaging processes	
	Depict the physics of sensorics	
	Explain linear and non-linear filtering of signals	
	Establish interdisciplinary connections in the subject area and arrange them in their context	
	 Interpret effects of the most important classes of imaging sensors and displays using mathematical methods and models. 	physio
Skills	Students are able to	
	Use highly sophisticated methods and procedures of the subject area	
	 Identify problems and develop and implement creative solutions. 	
	Students can solve simple arithmetical problems relating to the specification and design of image processing and image	analy
	systems.	
	Students are able to assess different solution approaches in multidimensional decision-making areas.	
	Students can undertake a prototypical analysis of processes in Matlab.	
Personal Competence		
Social Competence	k.A.	
Autonomy	Students can solve image analysis tasks independently using the relevant literature.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement		
Examination	Written exam	
Examination duration and	60 Minutes, Content of Lecture and materials in StudIP	
scale		
	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory	
Following Curricula	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 Comp	-
	Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Software an	a Sigi
	Processing: Elective Compulsory	
	International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory	
	Microelectronics: specialisation intelligent systems and Robotics: Elective Compulsory Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Robotics 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	 Image representation, definition of images and volume data sets, illumination, radiometry, multispectral imaging reflectivities, shape from shading Perception of luminance and color, color spaces and transforms, color matching functions, human visual system, colo appearance models imaging sensors (CMOS, CCD, HDR, X-ray, IR), sensor characterization(EMVA1288), lenses and optics spatio-temporal sampling (interpolation, decimation, aliasing, leakage, moiré, flicker, apertures) features (filters, edge detection, morphology, invariance, statistical features, texture) optical flow (variational methods, quadratic optimization, Euler-Lagrange equations) segmentation (distance, region growing, cluster analysis, active contours, level sets, energy minimization and graph cuts) registration (distance and similarity, variational calculus, iterative closest points)
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 M1702: Proce	ss iniaging			
Courses				
Гitle	Тур		Hrs/wk	СР
Process Imaging (L2723)	Lectur	e	2	3
Process Imaging (L2724)	Project	t-/problem-based Learning	2	3
Module Responsible	Prof. Alexander Penn			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following lear	ning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
	Written exam			
	120 min			
scale				
Assignment for the	Bioprocess Engineering: Specialisation A - General Bioprocess Engineer	• • •		
Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineer			
	Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineer			
	Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineer			
	Bioprocess Engineering: Specialisation C - Bioeconomic Process Engin	ieering, Focus Energy and	Bioprocess	Technology: Elect
	Compulsory			
	Bioprocess Engineering: Specialisation C - Bioeconomic Process Engin	eering, Focus Energy and	Bioprocess	Technology: Elect
	Compulsory			
	Chemical and Bioprocess Engineering: Specialisation General Process E			
	Chemical and Bioprocess Engineering: Specialisation General Process E		-	
	Chemical and Bioprocess Engineering: Specialisation Bioprocess Engine			
	Chemical and Bioprocess Engineering: Specialisation Bioprocess Engine			
	Chemical and Bioprocess Engineering: Specialisation Chemical Process			
	Chemical and Bioprocess Engineering: Specialisation Chemical Process		pulsory	
	Computer Science: Specialisation II: Intelligence Engineering: Elective C			
	Information and Communication Systems: Specialisation Communicatio			
	International Management and Engineering: Specialisation II. Process E			Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Compu			
	Theoretical Mechanical Engineering: Specialisation Robotics and Compu		pulsory	
	Process Engineering: Specialisation Process Engineering: Elective Comp			
	Process Engineering: Specialisation Process Engineering: Elective Comp	-		
	Process Engineering: Specialisation Chemical Process Engineering: Elec			
	Process Engineering: Specialisation Chemical Process Engineering: Elec			
	Process Engineering: Specialisation Environmental Process Engineering			
	Process Engineering: Specialisation Environmental Process Engineering			
	Water and Environmental Engineering: Specialisation Environment: Elec			
	Water and Environmental Engineering: Specialisation Environment: Elec			
	Water and Environmental Engineering: Specialisation Water: Elective Co			
	Water and Environmental Engineering: Specialisation Water: Elective Co			

Course L2723: Process Imag	Course L2723: Process Imaging	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Penn	
Language	EN	
Cycle	SoSe	
Content		
Literature		

Course L2724: Process Imag	ourse L2724: Process Imaging	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Penn	
Language	EN	
Cycle	SoSe	
Content		
Literature		

Courses				
Title		Тур	Hrs/wk	СР
Compilers for Embedded Systems		Lecture	3	4
Compilers for Embedded Systems		Project-/problem-based Learning	1	2
Module Responsible				
Admission Requirements				
	Module "Embedded Systems"			
Knowledge	C/C++ Programming skills			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence	Alter taking part successiony, students have			
-	The relevance of embedded systems increa	ses from year to year. Within such systems, the amo	unt of softwa	e to be executed
nnomeage		ue to its lower costs and higher flexibility. Because		
		nd application-specific processors are deployed. S		
		ave to generate code of highest quality. After the su		
	the students are able			
	 to illustrate the structure and organiz 	ation of such compilers		
		te representations of various abstraction levels, and		
	 to assess optimizations and their und 			
	- · ·	dded systems make effective code optimizations	mandatory. Th	e students learn
	particular,			
	 which kinds of optimizations are appli 	cable at the source code level,		
	how the translation from source code	to assembly code is performed,		
	which kinds of optimizations are appli	cable at the assembly code level,		
	 how register allocation is performed, 	and		
	 how memory hierarchies can be explored 	bited effectively.		
		n have to optimize for multiple objectives (e.g., aver learn to evaluate the influence of optimizations on th		
Skills	be enabled to assess which kind of code opt assembly code) within a compiler.	udents shall be able to translate high-level program imization should be applied most effectively at whic arn to implement a fully functional compiler includin	h abstraction	level (e.g., source
			5 1	
Personal Competence				
Social Competence	Students are able to solve similar problems	alone or in a group and to present the results accord	ingly.	
Autonomy	Students are able to acquire new knowledge	from specific literature and to associate this knowle	dge with othe	r classes.
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Computer Science: Specialisation I. Compute	er and Software Engineering: Elective Compulsory		
Following Curricula		ation and Communication Systems: Elective Compul	sory	
	Aircraft Systems Engineering: Core qualifica	tion: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systemeters			
	Mechatronics: Specialisation System Design			
	Mechatronics: Technical Complementary Co			
		al Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Special	isation Robotics and Computer Science: Elective Con	npulsory	

Course L1692: Compilers for	Embedded Systems
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Heiko Falk
Language	DE/EN
Cycle	SoSe
Content	 Introduction and Motivation Compilers for Embedded Systems - Requirements and Dependencies Internal Structure of Compilers Pre-Pass Optimizations HIR Optimizations and Transformations Code Generation LIR Optimizations and Transformations Register Allocation WCET-Aware Compilation Outlook
Literature	 Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2 nd Edition, Springer, 2012. Steven S. Muchnick. Advanced Compiler Design and Implementation. Morgan Kaufmann, 1997. Andrew W. Appel. Modern compiler implementation in C. Oxford University Press, 1998.

Course L1693: Compilers for	Course L1693: Compilers for Embedded Systems	
Тур	Project-/problem-based Learning	
Hrs/wk	1	
СР	2	
Workload in Hours	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					
Title		Тур	Hrs/wk	СР	
Machine Learning and Data Mining	(L0340)	Lecture	2	4	
Machine Learning and Data Mining		Recitation Section (small)	2	2	
Module Responsible	NN				
Admission Requirements					
Recommended Previous					
Knowledge	Calculus				
	Stochastics				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results			
Professional Competence	· ····· ······························				
•	Students can explain the difference betwee	een instance-based and model-based learning a	pproaches, and they	/ can enumerate ba	
		of the two basic approaches, either on the b			
	- · ·	g with uncertainty, students can describe suita			
		ers, or structures used in these formalisms car			
	algorithms. Students are also able to sketch different clustering techniques. They depict how the performance of learned classifier can be improved by ensemble learning, and they can summarize how this influences computational learning theory. Algorithms fo				
	reinforcement learning can also be explai				
	5 1				
Skills Student derive decision trees and, in turn, propositional rule sets from simple and static data tables and			ic data tables and	are able to name a	
	explain basic optimization techniques. They present and apply the basic idea of first-order inductive leaning. Students apply the				
	BME, MAP, ML, and EM algorithms for lea	arning parameters of Bayesian networks and co	mpare the different	algorithms. They al	
	know how to carry out Gaussian mixtu	ure learning. They can contrast kNN classifier	s, neural networks	, and support vect	
		ion areas and algorithmic properties. Students			
	and explain the basic components of th	ose techniques. Students compare related ma	chine learning tech	niques, e.g., k-mea	
	clustering and nearest neighbor classifi	cation. They can distinguish various ensembl	e learning techniqu	ues and compare t	
	different goals of those techniques.				
Personal Competence					
Social Competence					
Autonomy					
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 minutes				
scale					
Assignment for the					
Following Curricula		ng: Specialisation II. Information Technology: Ele	ctive Compulsory		
	Mechatronics: Technical Complementary	Course: Elective Compulsory			
	Mechatronics: Specialisation System Desi				
		ystems and Robotics: Elective Compulsory			
	Theoretical Mechanical Engineering: Tech	inical Complementary Course: Elective Compulse	ory		
		ialisation Robotics and Computer Science: Elect			

Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	SoSe
Content	 Decision trees First-order inductive learning Incremental learning: Version spaces Uncertainty Bayesian networks Learning parameters of Bayesian networks BME, MAP, ML, EM algorithm Learning structures of Bayesian networks Gaussian Mixture Models kNN classifier, neural network classifier, support vector machine (SVM) classifier Clustering Distance measures, k-means clustering, nearest neighbor clustering Kernel Density Estimation Ensemble Learning Reinforcement Learning Computational Learning Theory
Literature	1. Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russel, Peter Norvig, Prentice Hall, 2010, Chapters 13, 14
	18-21 2. Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press 2012

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

Courses				
Title		Тур	Hrs/wk	СР
Approximation and Stability (L0487)	Lecture	3	4
Approximation and Stability (L0488)	Recitation Section (small)	1	2
Module Responsible	Prof. Marko Lindner			
Admission Requirements	None			
Recommended Previous Knowledge	 Linear Algebra: systems of linear equations, least squares problems, eigenvalues, singular values 			
Educational Objectives	After taking part successfully, students have read	hed the following learning results		
Professional Competence				
Knowledge	Students are able to			
	 sketch and interrelate basic concepts of fu 	nctional analysis (Hilbert space, operators)		
	 name and understand concrete approxima 			
	 name and explain basic stability theorems 			
	 discuss spectral quantities, conditions num 			
Personal Competence	Students are able to solve specific problems in groups and to present their results appropriately (e.g. as a seminar presentation).			
Workload in Hours	Independent Study Time 124, Study Time in Lect	ure 56		
Credit points	6			
Course achievement	Compulsory Bonus Form Yes None Presentation	Description		
Examination	Oral exam			
Examination duration and scale	20 min			
Assignment for the	Electrical Engineering: Specialisation Control and	Power Systems Engineering: Elective Comp	ulsory	
Following Curricula	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory		
	Technomathematics: Specialisation I. Mathematic	cs: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Co	mplementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation	n Robotics and Computer Science: Elective	Compulsory	

Course L0487: Approximatio	n and Stability	
Тур	Lecture	
Hrs/wk	3	
СР	4	
Workload in Hours	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	
	out 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	R. Hagen, S. Roch, B. Silbermann: C*-Algebras in Numerical Analysis	
	H. W. Alt: Lineare Funktionalanalysis	
	M. Lindner: Infinite matrices and their finite sections	

Course L0488: Approximatio	Course L0488: Approximation and Stability		
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	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses					
Title			Тур	Hrs/wk	СР
Humanoid Robotics (L0663)			Seminar	2	2
Module Responsible	Patrick Göttsch				
Admission Requirements	None				
Recommended Previous					
Knowledge	 Introduction to a 	control cyctome			
	Control theory a				
	• control theory c	ind design			
Educational Objectives	After taking part succe	essfully, students have reached	the following learning results		
Professional Competence					
Knowledge	 Students can ex 	plain humanoid robots.			
			for different tasks in humanoid	robotics	
Skills	 Students acquir 	e knowledge about selected a	spects of humanoid robotics, bas	ed on specified literature	
		alize developed results and pre			
	Students praction	ce to prepare and give a prese	ntation		
Demonal Commetence					
Personal Competence Social Competence					
Social Competence	 Students are ca 	pable of developing solutions i	n interdisciplinary teams and pre	esent them	
	 They are able to 	provide appropriate feedback	and handle constructive criticis	m of their own results	
Autonomy					
hatehenny	 Students evaluation 	ate advantages and drawbac	ks of different forms of present	tation for specific tasks	and select the be
	solution				
			tific field, are able of introduce i	it and follow presentation	ns of other studen
	such that a scie	ntific discussion develops			
Workload in Hours	Independent Study Tin	ne 32, Study Time in Lecture 2	8		
Credit points	2				
Course achievement	None				
Examination	Presentation				
Examination duration and	30 min				
scale					
Assignment for the	Mechatronics: Speciali	sation Intelligent Systems and	Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Speciali	sation System Design: Elective	e Compulsory		
	-		ins and Regenerative Medicine: E		
	-	•	Endoprostheses: Elective Compu	•	
	_		nology and Control Theory: Elect		
	-		and Business Administration: Ele		
		l Engineering: Technical Comp l Engineering: Specialisation R	lementary Course: Elective Com		

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

Module M0939: Contro				
Courses				
ītle		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 Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	 State space methods 			
	LQG control			
	 H2 and H-infinity optimal control 			
	 uncertain plant models and robu 	ist control		
	LPV control			
		har a secolar data faile data bar adam an ha		
-	After taking part successfully, students	have reached the following learning results		
Professional Competence				
Knowledge	 Students can explain the different 	nce between validation of a control lop in simulation	on and experimental v	alidation
Skills				
		ng basic system identification tools (Matlab Sys	stem Identification To	olbox) to identify
	dynamic model that can be used			
	 They are capable of using stan 	idard software tools (Matlab Control Toolbox) for	r the design and imp	elementation of L
	controllers			
	 They are capable of using stand 	ard software tools (Matlab Robust Control Toolbox) for the mixed-sensit	tivity design and t
	implementation of H-infinity opti	mal controllers		
	 They are capable of representing 	g model uncertainty, and of designing and implem	enting a robust contro	oller
	 They are capable of using standa 	ard software tools (Matlab Robust Control Toolbox)	for the design and th	e implementation
	LPV gain-scheduled controllers			
Personal Competence				
Social Competence	• Students can work in teams to c	onduct experiments and document the results		
		· · · · · · · · · · · · · · · · · · ·		
Autonomy	 Students can independently carr 	y out simulation studies to design and validate co	ntral loons	
	• Students can independently can	y our simulation studies to design and valuate co	ntroi loops	
Workload in Hours	Independent Study Time 64, Study Tim	e in Lecture 56		
Credit points	4			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	1			
scale				
Assignment for the	Electrical Engineering: Specialisation C	ontrol and Power Systems Engineering: Elective Co	ompulsory	
Following Curricula	Mechatronics: Specialisation System De	esign: Elective Compulsory		
	Mechatronics: Specialisation Intelligent	Systems and Robotics: Elective Compulsory		
	Theoretical Mechanical Engineering: Te	chnical Complementary Course: Elective Compuls	ory	
		pecialisation Robotics and Computer Science: Elect	•	

Course L1093: Control Lab I	
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	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

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Course L1291: Control Lab II	
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	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 L1665: Control Lab II	l de la construcción de la constru
Тур	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	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

ractical Course
ndependent Study Time 16, Study Time in Lecture 14
rof. Herbert Werner, Patrick Göttsch, Adwait Datar
N
ViSe/SoSe
ne of the offered experiments in control theory.
xperiment Guides
nd ro N

			Тур	Hrs/wk	СР
44)			Lecture	2	3
45)			Recitation Section (small)	2	3
Prof. Alexander Schl	aefer				
None					
		ds			
· · · ·					
	ims and data strue	tures			
programming skills					
After taking part suc	cessfully, student	s have reached the follow	ving learning results		
The students can ev	aluate and assess	discrete event systems.	They can evaluate properties	of processes and	explain methods
process analysis. Th	e students can co	mpare methods for proce	ess modelling and select an ap	propriate method	for actual problem
They can discuss scheduling methods in the context of actual problems and give a detailed explanation of advantages and					
disadvantages of di	ifferent programm	ing methods. The stude	ents can relate process auton	nation to method	ls from robotics a
sensor systems as w	vell as to recent to	pics like 'cyberphysical s	ystems' and 'industry 4.0'.		
The students are ab	le to develop and	model processes and ev	valuate them accordingly. This	involves taking	nto account optim
scheduling, understa	anding algorithmic	complexity, and implem	entation using PLCs.		
The students work in	n teams to solve p	roblems.			
The students can re	flect their knowled	lge and document the re	sults of their work.		
		5			
Independent Study	Time 124, Study T	ime in Lecture 56			
6					
Compulsory Bonus	Form	Description			
No 10 %	Excercises				
Written exam					
90 minutes					
Bioprocess Engineer	ring: Specialisatior	A - General Bioprocess I	Engineering: Elective Compulse	ory	
Chemical and Biopro	ocess Engineering	Specialisation Chemical	Process Engineering: Elective	Compulsory	
		•		ompulsory	
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-					ampulsors
5	5	5 1		action: Elective C	ompuisory
-					
-					
				Compulsory	
			•	compaisory	
Process Engineering	: Specialisation (1	nemical Process Engineer	ing: Elective Compulsory		
	A5) Prof. Alexander Schl None mathematics and op principles of automa principles of algorith programming skills After taking part suc The students can ev process analysis. Th They can discuss s disadvantages of di sensor systems as w The students are at scheduling, understa The students can re Independent Study 6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineer Chemical and Biopro Computer Science: S Electrical Engineer Aircraft Systems Eng International Manag International Manag Mechanical Ingineer Mechanical Mechani Theoretical Mechani	45) Prof. Alexander Schlaefer None mathematics and optimization method principles of algorithms and data struct programming skills After taking part successfully, student The students can evaluate and assess process analysis. The students can contract of the can discuss scheduling method disadvantages of different programming sensor systems as well as to recent to The students are able to develop and scheduling, understanding algorithmic The students can reflect their knowled Independent Study Time 124, Study Time 6 Compulsory Bonus No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation Chemical and Bioprocess Engineering: Computer Science: Specialisation II: In Electrical Engineering: Specialisation II	45) Prof. Alexander Schlaefer None mathematics and optimization methods principles of automata principles of algorithms and data structures programming skills After taking part successfully, students have reached the follow The students can evaluate and assess discrete event systems. process analysis. The students can compare methods for proce They can discuss scheduling methods in the context of act disadvantages of different programming methods. The stude sensor systems as well as to recent topics like 'cyberphysical s The students are able to develop and model processes and er scheduling, understanding algorithmic complexity, and implement The students work in teams to solve problems. The students can reflect their knowledge and document the rest Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 10 % Excercises Mitten exam 90 minutes Bioprocess Engineering: Specialisation A - General Bioprocess In Chemical and Bioprocess Engineering: Specialisation Chemical Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Specialisation Control and Power	44) Lecture Recitation Section (small) Prof. Alexander Schlaefer Recitation Section (small) None mathematics and optimization methods principles of automata principles of automata principles of algorithms and data structures programming skills After taking part successfully, students have reached the following learning results After taking part successfully, students have reached the following learning results The students can evaluate and assess discrete event systems. They can evaluate properties process analysis. The students can compare methods for process modelling and select an ap They can discuss scheduling methods. The students can relate process auton sensor systems as well as to recent topics like 'cyberphysical systems' and 'industry 4.0'. The students are able to develop and model processes and evaluate them accordingly. This scheduling, understanding algorithmic complexity, and implementation using PLCs. The students can reflect their knowledge and document the results of their work. Independent Study Time 124, Study Time in Lecture 56 6 Computery Bonus Form Description No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Hirtten exins Engineering: Specialisation Cabin Systems: Electiv	44) Lecture 2 45) Recitation Section (small) 2 Porf. Alexander Schlaefer 2 None 3 2 mathematics and optimization methods principles of algorithms and data structures programming skills 3 After taking part successfully, students have reached the following learning results 3 The students can evaluate and assess discrete event systems. They can evaluate properties of processes and process analysis. The students can compare methods for process modelling and select an appropriate method have can discuss scheduling methods. The students can relate process automation to method sensor systems as well as to recent topics like 'cyberphysical systems' and 'industry 4.0'. The students are able to develop and model processes and evaluate them accordingly. This involves taking is scheduling, understanding algorithmic complexity, and implementation using PLCs. The students can reflect their knowledge and document the results of their work. Independent Study Time 124, Study Time in Lecture 56 6 Computery Tools Port Description 90 minutes Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Speciali

Course L0344: Industrial Pro	cess Automation
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	 foundations of problem solving and system modeling, discrete event systems properties of processes, modeling using automata and Petri-nets design considerations for processes (mutex, deadlock avoidance, liveness) optimal scheduling for processes optimal decisions when planning manufacturing systems, decisions under uncertainty software design and software architectures for automation, PLCs
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 Pro	ourse L0345: Industrial Process Automation		
Тур	Recitation Section (small)		
Hrs/wk	2		
CP	3		
Workload in Hours	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 M1302: Appli			
Courses			
Title Applied Humanoid Robotics (L1794) Project-/problem-based Learning	Hrs/wk 6	CP 6
Module Responsible	Patrick Göttsch		
Admission Requirements	None		
Recommended Previous Knowledge	 Object oriented programming; algorithms and data structures Introduction to control systems Control systems theory and design Mechanics 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence Knowledge	 Students can explain humanoid robots. Students can explain the basic concepts, relationships and methods of forward- and invers Students learn to apply basic control concepts for different tasks in humanoid robotics. 	se kinematics	
Skills	 Students can implement models for humanoid robotic systems in Matlab and C++, and us other tasks. They are capable of using models in Matlab for simulation and testing these models if new robot system. They are capable of selecting methods for solving abstract problems, for which no star apply it successfully. 	cessary with C	++ code on the re
Personal Competence <i>Social Competence</i> <i>Autonomy</i>	 Students can develop joint solutions in mixed teams and present these. They can provide appropriate feedback to others, and constructively handle feedback on Students are able to obtain required information from provided literature sources, and lecture. They can independently define tasks and apply the appropriate means to solve them. 		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Credit points			
Course achievement	None		
	Written elaboration		
Examination duration and			
scale			
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsor Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory	lsory	

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

Courses					
Title		Тур	Hrs/wk	СР	
Digital Signal Processing and Digita		Lecture	3	4	
Digital Signal Processing and Digita		Recitation Section (large) 2	2	
Module Responsible	Prof. Gerhard Bauch				
Admission Requirements	None				
Recommended Previous	Mathematics 1-3				
Knowledge	Signals and Systems				
	 Fundamentals of signal and system 	theory as well as random processes.			
	Fundamentals of spectral transform	s (Fourier series, Fourier transform, Laplace tr	ansform)		
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results			
Professional Competence		~ ~			
Knowledge	The students know and understand basic	algorithms of digital signal processing. They a	are familiar with the s	spectral transforms	
	discrete-time signals and are able to de	scribe and analyse signals and systems in t	me and image doma	ain. They know ba	
	structures of digital filters and can ide	entify and assess important properties inc	luding stability. They	y are aware of t	
	effects caused by quantization of filter c	oefficients and signals. They are familiar wit	h the basics of adap	tive filters. They o	
	perform traditional and parametric method	ds of spectrum estimation, also taking a limite	d 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 (MMSE) criterion and				
		. based on the LMS or RLS algorithm. Furt		ts are able to app	
	methods of spectrum estimation and to ta	ke the effects of a limited observation window	into account.		
Personal Competence					
Social Competence	The students can jointly solve specific prol	plems.			
Autonomy	The students are able to acquire releva	ant information from appropriate literature	sources. They can a	control their level	
	knowledge during the lecture period by so	lving tutorial problems, software tools, clicker	system.		
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70			
Credit points	6				
Course achievement	None				
	Written exam				
	90 min				
scale					
-		rol and Power Systems Engineering: Elective C			
Following Curricula		pecialisation II. Engineering Science: Elective			
		Specialisation Communication Systems, Focus		ective Compulsory	
		Specialisation Mechatronics: Elective Computer	зогу		
	Mechatronics: Specialisation Intelligent Sy		u Electivo Compulson	,	
		alisation Communication and Signal Processing nical Complementary Course: Elective Compute		/	
	medical mechanical engineering: recht	incar complementary course. Elective Comput	JOLA		

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

Course L0447: Digital Signal	ourse L0447: Digital Signal Processing and Digital Filters		
Тур	Recitation Section (large)		
Hrs/wk	2		
CP	2		
Workload in Hours	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		

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Courses				
Title		Тур	Hrs/wk	СР
Advanced Topics in Control (L0661		Lecture	2	3
Advanced Topics in Control (L0662		Recitation Section (small)	2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous	H-infinity optimal control, mixed-sensitivity d	esign, linear matrix inequalities		
Knowledge				
	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	 Students can explain the advantages a 	and shortcomings of the classical gain schedu	uling approach	
		f nonlinear systems in the form of quasi-LPV s		
		formance conditions for LPV systems can be		onditions
	• They can explain how gridding techniq	ues can be used to solve analysis and synthe	esis problems for LP	/ systems
	 They are familiar with polytopic and 	LFT representations of LPV systems and s	some of the basic	synthesis techniqu
	associated with each of these model s	tructures		
	 Students can explain how graph the 	oretic concepts are used to represent the	communication top	ology of multiage
	systems			
	 They can explain the convergence pro 	perties of first order consensus protocols		
	 They can explain analysis and synthes 	is conditions for formation control loops invol	ving either LTI or LP	V agent models
	 Students can explain the state space r 	epresentation of spatially invariant distribute	ed systems that are	discretized accordi
	to an actuator/sensor array			
	 They can explain (in outline) the ext 	ension of the bounded real lemma to such	distributed systems	s and the associat
	synthesis conditions for distributed con	ntrollers		
Skills				
01110	 Students are capable of constructing 	LPV models of nonlinear plants and carry	out a mixed-sensit	ivity design of ga
	scheduled controllers; they can do this	using polytopic, LFT or general LPV models		
	 They are able to use standard software 	e tools (Matlab robust control toolbox) for the	se tasks	
	 Students are able to design distribute 	ed formation controllers for groups of agents	s with either LTI or	LPV dynamics, usir
	Matlab tools provided			
	 Students are able to design distributed 	I controllers for spatially interconnected syste	ems, using the Matla	b MD-toolbox
Personal Competence				
	Students can work in small groups and arrive	at joint results		
	Students are able to find required informatio		re software docume	ntation) and use it
Autonomy	solve given problems.	in in sources provided (lecture notes, interaction	e, soltware docume	ntation) and use it
	solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in	ecture 56		
Credit points				
Course achievement				
Examination				
Examination duration and	30 min			
scale				
-	Electrical Engineering: Specialisation Control		mpulsory	
Following Curricula	Aircraft Systems Engineering: Specialisation			
	Aircraft Systems Engineering: Specialisation			
	Aircraft Systems Engineering: Core qualificati			
	International Management and Engineering:		Juisory	
	Mechatronics: Specialisation System Design:			
	Mechatronics: Specialisation Intelligent Syste			
	Biomedical Engineering: Specialisation Impla			
	Biomedical Engineering: Specialisation Medic			
	Biomedical Engineering: Specialisation Manag	nement and Rusiness Administration. Elective	- compulsory	
	Biomedical Engineering: Specialisation Artific Theoretical Mechanical Engineering: Technica	ial Organs and Regenerative Medicine: Electi	ve Compulsory	

Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0661: Advanced Top	pics in Control	
Тур	Lecture	
Hrs/wk	2	
СР		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
Language	EN	
Cycle	WiSe	
Content	Linear Parameter-Varying (LPV) Gain Scheduling	
	- Linearizing gain scheduling, hidden coupling	
	- Jacobian linearization vs. quasi-LPV models	
	- Stability and induced L2 norm of LPV systems	
	- Synthesis of LPV controllers based on the two-sided projection lemma	
	- Simplifications: controller synthesis for polytopic and LFT models	
	- Experimental identification of LPV models	
	- Controller synthesis based on input/output models	
	- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator	
	Control of Multi-Agent Systems	
	- Communication graphs	
	- Spectral properties of the graph Laplacian	
	- First and second order consensus protocols	
	- Formation control, stability and performance	
	- LPV models for agents subject to nonholonomic constraints	
	- Application: formation control for a team of quadrotor helicopters	
	Linear and Nonlinear Model Predictive Control based on LMIs	
Literature	Werner, H., Lecture Notes "Advanced Topics in Control"	
	 Selection of relevant research papers made available as pdf documents via StudIP 	

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	

Courses						
Title		Тур	Hrs/wk	СР		
Intelligent Autonomous Agents and	I Cognitive Robotics (L0341)	Lecture	2	4		
Intelligent Autonomous Agents and	Cognitive Robotics (L0512)	Recitation Section (small)	2	2		
Module Responsible	Rainer Marrone					
Admission Requirements	None					
Recommended Previous	Vectors, matrices, Calculus					
Knowledge						
Educational Objectives	After taking part successfully, students have	e reached the following learning results				
Professional Competence		5 5				
		, define intelligence in terms of rational behav	or, and give detail	s about agent des		
		escribe the main features of environments. The				
		plems and algorithms for solving these problem				
		low Bayesian networks can be employed as a k	÷			
		In addition, students can define decision makin				
	settings, with and with complete access to	o the state of the environment. In this contex	t, students can de	scribe techniques		
	solving (partially observable) Markov decis	ion problems, and they can recall techniques	for measuring the	value of informat		
	Students can identify techniques for simul	taneous localization and mapping, and can ex	plain planning tech	hniques for achiev		
	desired states. Students can explain coordi	nation problems and decision making in a multi	-agent setting in te	erm of different ty		
	of equilibria, social choice functions, voting	ullibria, social choice functions, voting protocol, and mechanism design techniques.				
<i></i>						
Skills	's Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application					
		bly basic optimization techniques. For those app				
		l apply bayesian reasoning for simple querie				
		agent scenarios. For simple and complex dec				
		. In multi-agent situations students will apply t	•			
	the results.	decision making students will apply different vo	ning protocols and	compare and exp		
	the results.					
Personal Competence						
		to problems with others. They communicate in	Englich			
Social Competence	Students are able to discuss their solutions	to problems with others. They communicate in	English			
Autonomy	Students are able of checking their understa	anding of complex concepts by solving varaints	of concrete proble	ms		
Workload in Hours	Independent Study Time 124, Study Time ir	a Lecture 56				
Credit points						
Course achievement	None					
Examination	Written exam					
Examination duration and	90 minutes					
scale						
Assignment for the	Computer Science: Specialisation II: Intellige	ence Engineering: Elective Compulsory				
-		: Specialisation II. Information Technology: Elect	ive Compulsory			
-	Mechatronics: Technical Complementary Co					
	Mechatronics: Specialisation Intelligent Syst	tems and Robotics: Elective Compulsory				
		icial Organs and Regenerative Medicine: Electiv	e Compulsory			
		ants and Endoprostheses: Elective Compulsory				
	Biomedical Engineering: Specialisation Med	ical Technology and Control Theory: Elective Co	mpulsory			
	Biomedical Engineering: Specialisation Man	agement and Business Administration: Elective	Compulsory			
		agement and Business Administration: Elective cal Complementary Course: Elective Compulsor				

Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	 Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elemen chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, province, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complex independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax an etworks: Syntax an etworks: Byntax metworks: Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Mai assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanat special cases: hidden Markov models, Kalman filters, Exact inferences and approximations 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 Simultaneous Localization and Mapping Planning Game theory (Golden Balls: Split or Share) Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium Social Choice Voting protocols, preferences, paradoxes, Arrow's Theorem, Mechanism Design Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theor Direct mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthw Theorem
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 11, 13-17 Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005
	 Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambrid University Press, 2009

Course L0512: Intelligent Au	rse L0512: Intelligent Autonomous Agents and Cognitive Robotics	
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
Workload in Hours	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		Тур	Hrs/wk 3	CP 4
Mathematical Image Processing (L Mathematical Image Processing (L		Lecture Recitation Section (small)	3	2
Module Responsible		Rectation Section (Shair)	1	2
Admission Requirements				
	None			
Recommended Previous Knowledge	 Analysis: partial derivatives, gradien 	t, directional derivative		
Kilowieuge	Linear Algebra: eigenvalues, least so	uares solution of a linear system		
	After taking part successfully, students have	a reached the following learning results		
	After taking part successfully, students hav	e reached the following learning results		
Professional Competence	Students are able to			
Knowledge	Students are able to			
	characterize and compare diffusion e	equations		
	 explain elementary methods of image 	e processing		
	 explain methods of image segmenta 	tion and registration		
	 sketch and interrelate basic concept 	s of functional analysis		
Skills	Students are able to			
	implement and apply elementary me avalation and apply medars methods.			
	 explain and apply modern methods of 	or image processing		
Personal Competence				
Social Competence	Students are able to work together in	heterogeneously composed teams (i.e., teams	from different	tudy programs a
	background knowledge) and to explain the	pretical foundations.		
Autonomy	• Students are capable of checking the	eir understanding of complex concepts on their	own. They can sp	ecify open questi
	precisely and know where to get hel	o in solving them.		
	Students have developed sufficient	persistence to be able to work for longer period	ds in a goal-orien	ted manner on h
	problems.			
Workload in Hours	Independent Study Time 124, Study Time i	a Lecture 56		
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and	20 min			
scale				
	Bioprocess Engineering: Specialisation A - (General Bioprocess Engineering: Elective Compul	sorv	
-	Computer Science: Specialisation III. Mathe			
		pecialisation III. Mathematics: Elective Compulsor	у	
		n Computational Methods in Biomedical Imaging	-	
	Mechatronics: Technical Complementary Co			
	Mechatronics: Specialisation System Design			
	Mechatronics: Specialisation Intelligent Sys			
	Technomathematics: Specialisation I. Math	ematics: Elective Compulsory		
	Theoretical Mechanical Engineering: Techn	cal Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specia	lisation Robotics and Computer Science: Elective	Compulsory	
	Process Engineering: Specialisation Process	Engineering, Elective Compulson		

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

ourses			
Title	Тур	Hrs/wk CP	
Module Responsible	Prof. Robert Seifried		
Admission Requirements	None		
Recommended Previous	see FSPO		
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	see FSPO		
Autonomy	see FSPO		
Workload in Hours	Depends on choice of courses		
Credit points	6		
Assignment for the	Theoretical Mechanical Engineering: Specialisation Product Development and	nd Production: Elective Compulsory	
Following Curricula	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engine	ering: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Materials Science: Election	ve Compulsory	
	Theoretical Mechanical Engineering: Specialisation Maritime Technology: El	ective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Energy Systems: Electiv	e Compulsory	
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technol	logy: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer	Science: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Simulation Technology:	Elective Compulsory	

Specialization Simulation Technology

Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Structural Analysis (L027	7)	Lecture	3	4
Nonlinear Structural Analysis (L027		Recitation Section (small)	1	2
Module Responsible	Prof. Alexander Düster			
Admission Requirements	None			
	Knowledge of partial differential equations is recomm	nended.		
Knowledge				
Educational Objectives	After taking part successfully, students have reached	I the following learning results		
Professional Competence				
	Students are able to			
-	+ give an overview of the different nonlinear phenon	nena in structural mechanics.		
	+ explain the mechanical background of nonlinear pl	nenomena in structural mechanics.		
	+ to specify problems of nonlinear structural analysi		and to explain the	eir mathematical ar
	mechanical background.			
Skille	Students are able to			
JKIIIS	+ model nonlinear structural problems.			
	+ select for a given nonlinear structural problem a su	uitable computational procedure		
	+ apply finite element procedures for nonlinear struct			
	+ critically verify and judge results of nonlinear finite			
	+ to transfer their knowledge of nonlinear solution pr			
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous groups and to do	cument the corresponding results.		
	+ share new knowledge with group members.			
Autonomy	Students are able to			
,	+ acquire independently knowledge to solve complex	x problems.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Civil Engineering: Specialisation Structural Engineering	ng: Elective Compulsory		
Following Curricula	International Management and Engineering: Specialis	sation II. Civil Engineering: Elective Com	pulsory	
	Materials Science: Specialisation Modeling: Elective C	Compulsory		
	Mechatronics: Specialisation System Design: Elective	Compulsory		
	Product Development, Materials and Production: Core	e qualification: Elective Compulsory		
	Naval Architecture and Ocean Engineering: Core qua	lification: Elective Compulsory		
	Ship and Offshore Technology: Core qualification: Ele	ctive Compulsory		
	Theoretical Mechanical Engineering: Technical Comp	lementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Si	mulation Technology: Elective Compuls	ory	

Course L0277: Nonlinear Str	uctural Analysis
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/EN
Cycle	WiSe
Content	1. Introduction
	2. Nonlinear phenomena
	3. Mathematical preliminaries
	4. Basic equations of continuum mechanics
	5. Spatial discretization with finite elements
	6. Solution of nonlinear systems of equations
	7. Solution of elastoplastic problems
	8. Stability problems
	9. Contact problems
Literature	[1] Alexander Düster, Nonlinear Structrual Analysis, Lecture Notes, Technische Universität Hamburg-Harburg, 2014.
	[2] Peter Wriggers, Nonlinear Finite Element Methods, Springer 2008.
	[3] Peter Wriggers, Nichtlineare Finite-Elemente-Methoden, Springer 2001.
	[4] Javier Bonet and Richard D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press,
	2008.

Course L0279: Nonlinear Str	ourse L0279: Nonlinear Structural Analysis	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
Workload in Hours	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: Mate	rials Modeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear and nonlinear continuum mechanic	s as taught, e.g., in the modules Mechanic	s II and Continuu	um Mechanics (forc
Knowledge	and moments, stress, linear and nonlinear strain, f	ee-body principle, linear and nonlinear cor	nstitutive laws, st	rain energy)
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge	The students can explain the fundamentals of mult	idimensional consitutive material laws		
Skills	The students can implement their own material law	vs in finite element codes. In particular, th	e students can a	pply their knowled
	to various problems of material science and evaluate the corresponding material models.			
Personal Competence				
Social Competence	The students are able to develop solutions, to pres	ent them to specialists and to develop idea	is further.	
Autonomy	The students are able to assess their own strength	s and weaknesses. They can independentl	y and on their o	wn identify and sol
	problems in the area of materials modeling and ac	quire the knowledge required to this end.		
Workload in Hours	Independent Study Time 124, Study Time in Lectur	e 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective	Compulsory		
Following Curricula	Mechanical Engineering and Management: Speciali	sation Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Org	gans and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants an	d Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Tec	hnology and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management	nt and Business Administration: Elective Co	mpulsory	
	Product Development, Materials and Production: Co	ore qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation	Materials Science: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation	Simulation Technology: Elective Compulso	ry	

Course L1535: Material Mode	eling
Тур	Lecture
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	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	

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Course L1536: Material Mode	urse 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		

Courses				
Fitle		Тур	Hrs/wk	СР
agrangian transport in turbulent fl		Lecture	2	3
Computational Fluid Dynamics - Ex Computational Fluid Dynamics in P		Recitation Section (small) Lecture	1 2	1 2
Module Responsible		2000.0	_	-
Admission Requirements	None			
Recommended Previous				
Knowledge	Mathematics I-IV			
	 Basic knowledge in Fluid Mechanics 			
	Basic knowledge in chemical thermodynam	nics		
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	After successful completion of the module the stu	idents are able to		
	explain the the basic principles of statistica			
	describe the main approaches in classical I	•	ar Dynamics) in var	nous ensemples
	discuss examples of computer programs in			
	 evaluate the application of numerical simu list the possible start and boundary conditi 			
	Ist the possible start and boundary condition			
Skills	The students are able to:			
	 set up computer programs for solving simp 	le problems by Monte Carlo or molecular	dynamics,	
	 solve problems by molecular modeling, 			
	 set up a numerical grid, 			
	 perform a simple numerical simulation with 	n OpenFoam,		
	evaluate the result of a numerical simulation	on.		
Personal Competence				
	The students are able to			
	 develop joint solutions in mixed teams and 		nts,	
	 to collaborate in a team and to reflect their 	r own contribution toward it.		
Autonomy	The students are able to:			
	 evaluate their learning progress and to def 	ine the following steps of learning on the	t basis.	
	 evaluate chen learning progress and to der evaluate possible consequences for their p 			
	Independent Study Time 110, Study Time in Lectu	ure 70		
Credit points Course achievement				
Examination	Oral exam			
	30 min			
scale	50 mm			
	Bioprocess Engineering: Specialisation A - Genera	l Bioprocess Engineering: Elective Comp	ulsory	
Following Curricula	Bioprocess Engineering: Specialisation B - Industr			
ytulu	Chemical and Bioprocess Engineering: Specialisat			
	Chemical and Bioprocess Engineering: Specialisat			
	Energy and Environmental Engineering: Specialise			ulsory
	Theoretical Mechanical Engineering: Technical Co			
	Theoretical Mechanical Engineering: Specialisatio			
		n Simulation Technology: Elective Compu	llsory	
	medical mechanical Engineering. Specialisatio			
	Process Engineering: Specialisation Chemical Proc		,	

Course L2301: Lagrangian transport in turbulent flows	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. 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 methods (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
	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. $ ightarrow$ 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. \rightarrow Knowledge, social competence
	Required knowledge:
	Fluid mechanics 1 and 2 advantageous
	Programming knowledge advantageous
Literature	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.
	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. DOI: 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
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Michael Schlüter
Language	EN
Cycle	SoSe
Content	 generation of numerical grids with a common grid generator selection of models and boundary conditions basic numerical simulation with OpenFoam within the TUHH CIP-Pool
Literature	OpenFoam Tutorials (StudIP)

	I Fluid Dynamics in Process Engineering	
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	ndependent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Michael Schlüter	
Language	EN	
Cycle	SoSe	
Content	 Introduction into partial differential equations Basic equations Boundary conditions and grids Numerical methods Finite difference method Finite volume method Time discretisation and stability Population balance Multiphase Systems Modeling of Turbulent Flows Exercises: Stability Analysis Exercises: Example on CFD - analytically/numerically 	
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 M0605: Comp	utational Structural Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Computational Structural Dynamics (L0282)		Lecture	3	4
Computational Structural Dynamics	(L0283)	Recitation Section (small)	1	2
Module Responsible	Prof. Alexander Düster			
Admission Requirements	None			
Recommended Previous	Knowledge of partial differential equations is	recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	Students are able to			
	+ give an overview of the computational proc	cedures for problems of structural dynamics.		
	+ explain the application of finite element pro	ograms to solve problems of structural dynamics	5.	
	+ specify problems of computational structure	ral dynamics, to identify them in a given situat	ion and to explai	n their mathemati
	and mechanical background.			
Skille	Students are able to			
JKIIIS	+ model problems of structural dynamics.			
	+ select a suitable solution procedure for a gi	iven problem of structural dynamics		
	+ apply computational procedures to solve pr			
	+ verify and critically judge results of comput	-		
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous groups ar	nd to document the corresponding results.		
Autonomy	Students are able to			
Autonomy	+ acquire independently knowledge to solve complex problems.			
	r dequire macpendently knowledge to solve			
Workload in Hours	Independent Study Time 124, Study Time in L	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2h			
scale				
Assignment for the	International Management and Engineering: S	Specialisation II. Mechatronics: Elective Compuls	sory	
Following Curricula	Materials Science: Specialisation Modeling: El	ective Compulsory		
	Mechatronics: Technical Complementary Cou	rse: Elective Compulsory		
	Naval Architecture and Ocean Engineering: C	ore qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technica	al Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialis	ation Simulation Technology: Elective Compuls	251	

Course L0282: Computational 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	1. Motivation	
	2. Basics of dynamics	
	3. Time integration methods	
	4. Modal analysis	
	5. Fourier transform	
	6. Applications	
Literature	[1] KJ. Bathe, Finite-Elemente-Methoden, Springer, 2002.	
	[2] J.L. Humar, Dynamics of Structures, Taylor & Francis, 2012.	

Course L0283: Computationa	urse L0283: Computational Structural Dynamics		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
Workload in Hours	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		Тур	Hrs/wk	СР	
Fundamentals of High-Performance	e Computing (L0242)	Lecture	2	3	
Fundamentals of High-Performance	e Computing (L1416)	Project-/problem-based Learn	ng 2	3	
Module Responsible	Prof. Thomas Rung				
Admission Requirements	None				
Recommended Previous	 Basic knowledge in usage of moder 	n IT environment			
Knowledge	Programming skills				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	e Students are able to outline the fundamentals of numerical algorithms for high-performance computers by reference to moder				
	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					
Social Competence	Students are able to develop and code algorithms in a team.				
Autonomy					
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written exam	Written exam			
Examination duration and	1.5h				
scale					
Assignment for the	Naval Architecture and Ocean Engineering	g: Core qualification: Elective Compulsory			
Following Curricula	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Spec	ialisation Simulation Technology: Elective Compuls	nrv		

Course L0242: Fundamentals	s of High-Performance Computing		
Тур	Lecture		
Hrs/wk			
СР	3		
Workload in Hours	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	ourse L1416: Fundamentals of High-Performance Computing		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	3		
Workload in Hours	dependent 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					
Title		Тур	Hrs/wk	СР	
Numerical Algorithms in Structural Mechanics (L0284)		Lecture	2	3	
Numerical Algorithms in Structural	Mechanics (L0285)	Recitation Section (small)	2	3	
Module Responsible	Prof. Alexander Düster	rof. Alexander Düster			
Admission Requirements	None				
Recommended Previous	Knowledge of partial differential equations is re	commended.			
Knowledge					
Educational Objectives	After taking part successfully, students have re	ached the following learning results			
Professional Competence					
Knowledge	Students are able to				
	+ give an overview of the standard algorithms	hat are used in finite element programs.			
	+ explain the structure and algorithm of finite e	lement programs.			
	+ specify problems of numerical algorithms, to	identify them in a given situation and to exp	ain their mathem	natical and compute	
	science background.				
Skille	Students are able to				
JKIIIS	+ construct algorithms for given numerical methods.				
	+ select for a given problem of structural mech				
	+ apply numerical algorithms to solve problems	•			
	+ implement algorithms in a high-level program				
	+ critically judge and verfiy numerical algorithm				
Personal Competence					
Social Competence	Students are able to				
	+ solve problems in heterogeneous groups and	to document the corresponding results.			
Autonomy	Students are able to				
, aconomy	+ acquire independently knowledge to solve co	mplex problems.			
	·				
Workload in Hours	Independent Study Time 124, Study Time in Lee	ture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	2h				
scale					
Assignment for the	Materials Science: Specialisation Modeling: Elec	tive Compulsory			
Following Curricula	Naval Architecture and Ocean Engineering: Cor	e qualification: Elective Compulsory			
	Technomathematics: Specialisation III. Engineer	ing Science: Elective Compulsory			
	Theoretical Mechanical Engineering: Technical	Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisat	ion Simulation Technology: Elective Compulse	rv		

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

Course L0285: Numerical Alg	urse L0285: Numerical Algorithms in Structural Mechanics		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	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		

<u> </u>					
Courses					
Title	、		Тур	Hrs/wk	СР
Boundary Element Methods (L0523			Lecture Recitation Section (large)	2	3 3
Boundary Element Methods (L0524			Recitation Section (large)	Z	3
Module Responsible					
Admission Requirements	None				
			nics II (Hydrostatics, Kinematics, Dyn	amics)	
Knowledge	Mathematics I, II, III (in particular differential equations)				
Educational Objectives	After taking part successfu	y, students have reached th	e following learning results		
Professional Competence					
Knowledge	The students possess an i	-depth knowledge regarding	, the derivation of the boundary elen	nent method and	d are able to give
		and methodical basis of the			
	overview of the theoretical				
Skills	The students are capabl	to handle engineering p	roblems by formulating suitable b	oundary eleme	nts, assembling f
	corresponding system mat	ces, and solving the resultir	g system of equations.		
Personal Competence					
	Students can work in small	arouns on specific problems	to arrive at joint solutions		
		groups on specific prosterins			
Autonomy	The students are able to independently solve challenging computational problems and develop own boundary element routines				
	Problems can be identified and the results are critically scrutinized.				
Workload in Hours	Independent Study Time 12	4, Study Time in Lecture 56			
Credit points	6				
Course achievement	Compulsory Bonus Form	Desc	iption		
	No 20 % Mid	erm			
Examination	Written exam				
Examination duration and	90 min				
scale					
	Civil Engineering: Specialis	tion Structural Engineering	Elective Compulsory		
-					
Following Curricula		tion Geotechnical Engineeri	• • •		
		tion Coastal Engineering: El			
		ication: Elective Compulsor			
			n Product Development and Productio	n: Elective Comp	oulsory
	Mechatronics: Specialisatio	System Design: Elective Co	mpulsory		
	Product Development, Mate	rials and Production: Core q	ualification: Elective Compulsory		
	Technomathematics: Speci	lisation III. Engineering Scie	nce: Elective Compulsory		
		J J			
			entary Course: Elective Compulsory		

Course L0523: Boundary Eler	ment Methods	
Тур	Lecture	
Hrs/wk		
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
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	
	//ppicodono	
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 Ele	urse L0524: Boundary Element Methods		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	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: Hiera	rchical Algorithms			
Courses				
Title		Тур	Hrs/wk	СР
Hierarchical Algorithms (L0585)		Lecture	2	3
Hierarchical Algorithms (L0586)		Recitation Section (small)	2	3
Module Responsible	Prof. Sabine Le Borne			
Admission Requirements	None			
Recommended Previous Knowledge	 Mathematics I, II, III for Engineering students (german or english) or Analysis & Linear Algebra I + II as well as Analysis III fo Technomathematicians Programming experience in C 			
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
Knowledge	 Students are able to name representatives of hierarchical algorithms and list their characteristics, explain construction techniques for hierarchical algorithms, discuss aspects regarding the efficient implementation of hierarchical algorithms. 			
Skills	Students are able to			
	 implement the hierarchical algorithms discussed in the lecture, analyse the storage and computational complexities of the algorithms, adapt algorithms to problem settings of various applications and thus develop problem adapted variants. 			
Personal Competence				
Social Competence	Students are able to			
	 work together in heterogeneously composed explain theoretical foundations and support e 			
Autonomy	Students are capable			
	 to assess whether the supporting theoretical to work on complex problems over an extend to assess their individual progess and, if nece 	ed period of time,	l individually or in	a team,
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Computer Science: Specialisation III. Mathematics: E	lective Compulsory		
Following Curricula	Technomathematics: Specialisation I. Mathematics:	Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Comp	elementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation S	imulation Technology: Elective Compulso	ory	
Course L0585: Hierarchical A	-			
Тур				
Hrs/wk	2			

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

Course L0586: Hierarchical A	rse 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		

Courses				
Title Numerics of Partial Differential Equ	actions (11247)	Typ Lecture	Hrs/wk	CP 3
Numerics of Partial Differential Equ		Recitation Section (small)	2	3
Module Responsible				-
Admission Requirements				
Recommended Previous Knowledge	 Mathematik I - IV (for Engineering Students) or Analysis & Linear Algebra L + II for Technomathematicians 			
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	 Students can classify partial differential equations according to the three basic types. For each type, students know suitable numerical approaches. Students know the theoretical convergence results for these approaches. 			
	S Students are capable to formulate solution strategies for given problems involving partial differential equations, to comment theoretical properties concerning convergence and to implement and test these methods in practice.			
Personal Competence				
Social Competence	Students are able to work together in heterogeneously composed teams (i.e., teams from different study programs background knowledge) and to explain theoretical foundations.			study programs a
Autonomy	 Students are capable of checking their understanding of complex concepts on their own. They can specify open questi precisely and know where to get help in solving them. Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on h problems. 			
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			
Assignment for the	Computer Science: Specialisation III. Math	nematics: Elective Compulsory		
Following Curricula	Technomathematics: Specialisation I. Mat	hematics: Elective Compulsory		
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Spec	ialisation Simulation Technology: Elective Compulso	bry	

Course L1247: Numerics of P	Partial Differential Equations
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Daniel Ruprecht
Language	DE/EN
Cycle	WiSe
Content	Elementary Theory and Numerics of PDEs types of PDEs well posed problems finite differences finite elements finite volumes applications
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 P	rse L1248: Numerics of Partial Differential Equations		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Daniel Ruprecht		
Language	DE/EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0720: Matri	x Algorithms				
	5				
Courses					
Гitle		Тур		Hrs/wk	СР
Matrix Algorithms (L0984)		Lecture		2	3
Matrix Algorithms (L0985)		Recitation Se	ection (small)	2	3
Module Responsible	·				
Admission Requirements	None				
Recommended Previous	Mathematics I - III				
Knowledge	Numerical Mathematics 1/ Numerics				
	Basic knowledge of the programming	g languages Matlab and C			
Educational Objectives	After taking part successfully, students hav	a reached the following learning r	osults		
Professional Competence	After taking part successfully, students hav	e reached the following learning r	esuits		
	Students are able to				
Khowicuge					
	1. name, state and classify state-of-the				is of the engineer
	sciences, namely, eigenvalue proble			on;	
	2. state approaches for the solution of	matrix equations (Sylvester, Lyap	unov, Riccati).		
Skills	Skills Students are capable to				
	 implement and assess basic Krylov reduction: 	subspace methods for the solutio	on of eigenvalue	problems, linear	systems, and mo
	 assess methods used in modern soft 	ware with respect to computing ti	me stability an	d domain of appli	cability
	 adapt the approaches learned to new 		me, stability, an	a domain or apply	cability,
Personal Competence					
Social Competence	Students can				
	 develop and document joint solution 	s in small teams:			
	• form groups to further develop the id		reas of applicabi	lity;	
	 form a team to develop, build, and a 				
Autonomy	Students are able to				
	 correctly assess the time and effort 	of self-defined work;			
	 assess whether the supporting theor 		e better solved ir	ndividually or in a	team;
	define test problems for testing and	expanding the methods;			
	• assess their individual progess and,	if necessary, to ask questions and	seek help.		
Workload in Hours	Independent Study Time 124, Study Time i	n Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	25 min				
scale					
Assignment for the	'				
Following Curricula	Theoretical Mechanical Engineering: Techn				
	Theoretical Mechanical Engineering: Specia	lisation Simulation Technology: El	ective Compulso	bry	

Course L0984: Matrix Algorit	ourse L0984: Matrix Algorithms		
Тур	Lecture		
Hrs/wk			
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	 Part A: Krylov Subspace Methods: Basics (derivation, basis, Ritz, OR, MR) Arnoldi-based methods (Arnoldi, GMRes) Lanczos-based methods (Lanczos, CG, BiCG, QMR, SymmLQ, PvL) Sonneveld-based methods (IDR, BiCGStab, TFQMR, IDR(s)) Part B: Matrix Equations: Sylvester Equation Lyapunov Equation Algebraic Riccati Equation 		
Literature	Skript		

Course L0985: Matrix Algorit	e L0985: Matrix Algorithms		
Тур	Recitation Section (small)		
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			
Literature	Siehe korrespondierende Vorlesung		

Courses					
Title			Тур	Hrs/wk	СР
Application of Innovative CFD Meth			Lecture	2	3
Application of Innovative CFD Meth		velopment (L1685)	Recitation Section (small)	2	3
Module Responsible					
Admission Requirements		outational fluid dunamics cour			
Kecommended Previous Knowledge	Attenuance of a comp	putational fluid dynamics cour	se (CFDI/CFD2)		
Kilowieuge	Competent knowledge of numerical analysis in addition to general and computational thermo/fluid dynamics				
Educational Obiectives	After taking part successfully, students have reached the following learning results				
Professional Competence	51.	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			
Knowledge	Student can explain the theoretical background of different CFD strategies (e.g. Lattice-Boltzmann, Smoothed Pa			Smoothed Partic	
	Hydrodynamics, Finit	e-Volume methods) and descr	ibe the fundamentals of simulation-based	optimisation.	
<i></i>					
	Student is able to identify an appropriate CFD-based solution strategy on a jusitfied basis.				
Personal Competence	Student should practice har/his team warking shiliting learn to lead team consider and present lutions to our site				
	Student should practice her/his team-working abilities, learn to lead team sessions and present solutions to experts. Student should be able to structure and perform a simulation-based project independently,				
· · · · · · · · · · · · · · · · · · ·	Independent Study Time 124, Study Time in Lecture 56				
Credit points		ine 124, Study fine in Lectur			
Course achievement	Compulsory Bonus	Form	Description		
	Yes 20 %	Written elaboration			
Examination	Oral exam				
Examination duration and	30 min				
scale					
Assignment for the	Energy Systems: Core	e qualification: Elective Compu	Ilsory		
Following Curricula	Naval Architecture ar	nd Ocean Engineering: Core qu	alification: Elective Compulsory		
	•	chnology: Core qualification: E			
			plementary Course: Elective Compulsory		
			Simulation Technology: Elective Compulso	ory	
	Process Engineering:	Specialisation Process Engine	ering: Elective Compulsory		

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	Course L1685: Application of Innovative CFD Methods in Research and Development		
Тур	Recitation Section (small)		
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	See interlocking course		
Literature	See interlocking course		

Courses				
litle		Тур	Hrs/wk	СР
Aultiscale simulation of granular m	aterials (L1858)	Lecture	2	2
Multiscale simulation of granular materials (L1860)		Recitation Section (small)	2	2
hermodynamic and kinetic modeli	ng of the solid state (L1859)	Lecture	2	2
Module Responsible	Prof. Maksym Dosta			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals in Mathematocs, Physics and Mecl	nanics		
Educational Objectives	After taking part successfully, students have read	ched the following learning results		
Professional Competence				
Knowledge				
	After successful completion of the module the st	udents are able to:		
	 describe modern modeling approaches whether the second seco	ich can be applied for simulation of granular	materials	
	 analyze and evaluate possibility to apply 	numerical simulations on different time a	nd length scales	: from description
	single particle properties on micro scale u	p to process simulation on macro scale		
	 list modern simulation system and discuss 	possibility of their application		
	 explain fundamentals of main numerical n 	nethods which are used for modeling of parti	culate materials	
	list experimental methods to characterize granular materials			
	explain fundamental thermodynamic and			
	 explain theoretical background and limitat 	ions of the discrete models for the processes	s with solids	
Skills				
	After successful completion of the module the st	udents are able to,		
	 perform flowsheet simulation of solids pro 	cesses and analyze steady-state or dynamic	process behavio	r
	 simulate behavior of granular materials or 			
	 optimize processes of mechanical process 			
	apply multiscale simulations for modeling			
	evaluate results of numerical simulations			
	 select and apply appropriate thermodynar 	nic and kinetic models for processes with sol	ids	
	 select and apply appropriate discrete mod 	els for the processes with solids.		
Personal Competence				
Social Competence				
	After completion of this module, participants wi	Il be able to debate technical questions in s	small teams to e	nhance the ability
	take position to their own opinions and increase	their capacity for teamwork.		-
Autonomy	After completion of this methods, methods at the	Il be able to colve a technical anable of the	nondontly instal	ing a proceeded in
	After completion of this module, participants wi the results. They are able to work out the know			
	existing knowledge from the lecture.	nedge that is necessary to solve the proble	in by themselve	
Workload in Hours	Independent Study Time 96, Study Time in Lectu	re 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the				
Following Curricula	Chemical and Bioprocess Engineering: Specialisa	tion General Process Engineering, Elective C	ompulsory	

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

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

Course L1859: Thermodynam	nic and kinetic modeling of the solid state
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Pavel Gurikov
Language	EN
Cycle	WiSe
Content	
	 Thermodynamics of pure solids: melting/crystallization; glassy and amorphous state. Thermodynamics of solid-gas equilibria: adsorption and sublimation. Thermodynamics of solid-liquid equilibria: solubility in aqueous and non-aqueous systems; solid solutions; supercritical fluids as solvents. Kinetics of dissolution/precipitation processes: chemical vapor deposition; drug release; hydrothermal processes. Characterization of solids: contact angle, adsorption techniques, IR spectroscopy, electron microscopy. Discrete models of dissolution/precipitation processes: diffusion limited aggregation; random-like and ballistic-like deposition models Advanced discrete models: surface wettability; adsorption and precipitation of (bio)polymers.
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.

urses				
ïtle		Тур	Hrs/wk	СР
Module Responsible	Prof. Robert Seifried	••		
Admission Requirements	None			
Recommended Previous	see FSPO			
Knowledge				
Educational Objectives	After taking part successfully, students have r	eached the following learning results		
Professional Competence				
Knowledge	see FSPO			
Skills	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	Theoretical Mechanical Engineering: Specialis	ation Product Development and Produc	tion: Elective Compulsory	
Following Curricula	Theoretical Mechanical Engineering: Specialis	ation Aircraft Systems Engineering: Ele	ective Compulsory	
	Theoretical Mechanical Engineering: Specialis	ation Materials Science: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Specialis	ation Maritime Technology: Elective Co	mpulsory	
	Theoretical Mechanical Engineering: Specialis	ation Energy Systems: Elective Compu	lsory	
	Theoretical Mechanical Engineering: Specialis	ation Bio- and Medical Technology: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Specialis	ation Robotics and Computer Science:	Elective Compulsory	
	Theoretical Mechanical Engineering: Specialis	ation Simulation Technology: Elective (Compulsory	

Supplement Modules

Modulo M0911, Modic	cal Imaging Systems			
Module M0811: Medic	ar imaging systems			
Courses				
Title	Typ Hrs/wk CP			
Medical Imaging Systems (L0819)	Lecture 4 6			
Module Responsible	Dr. Michael Grass			
Admission Requirements	None			
Recommended Previous	none			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge				
	Students can:			
	 Describe the system configuration and components of the main clinical 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 use with the fundamental physical equations;			
	 Name and describe the physical effects required to generate image contrasts; 			
	 Explain how spatial and temporal resolution can be influenced and how to 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.			
Skills	s Students are able to:			
	• Explain the physical processes of images and assign to the systems the basic mathematical 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 spatial and temporal resolution of imaging systems; 			
	 Explain the importance of different imaging systems for a number of clinical applications; 			
	Select a suitable imaging system for an application.			
Personal Competence				
Social Competence	none			
Autonomy	Students can:			
	 Understand which physical effects are used in medical imaging; 			
	Decide independently for which clinical issue a measuring system can be used.			
	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
	Written exam			
Examination duration and scale				
Assignment for the	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory			
Following Curricula	Biomedical Engineering: 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: Elective Compulsory			
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0819: Medical Imagi	ing Systems
	Lecture
Hrs/wk	4
СР	6
Workload in Hours	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.

	tics and Naviga	ation in Medicii	ne			
Courses						
Title			Тур		Hrs/wk	СР
Robotics and Navigation in Medicine (L0335)			Lecture		2	3
Robotics and Navigation in Medicine (L0338)			Project Se	eminar	2	2
Robotics and Navigation in Medicir	tics and Navigation in Medicine (L0336) 1 1				1	
Module Responsible	Prof. Alexander Schla	aefer				
Admission Requirements	None					
Recommended Previous						
Knowledge	 principles of m 	nath (algebra, analysis	/calculus)			
	 principles of p 	programming, e.g., in J	ava or C++			
	 solid R or Matl 	lab skills				
Educational Objectives	After taking part suc	rcessfully students ha	ve reached the following learnin	a results		
Professional Competence	, incer taking part suc	costany, stadents na		greballo		
-	The students can e	volain kinematics and	tracking systems in clinical co	ontexts and illustra	to systems and	their components
Kilowieuge			spect to collision detection an		-	
	-	lesign and limitations.	spect to considir detection an		ulations. Student	
	systems regarding u	esign and innitations.				
Skills	The students are abl	e to design and evalua	ate navigation systems and robo	otic systems for me	dical applications	
Personal Competence						
Social Competence	The students discuss	s the results of other g	roups, provide helpful feedback	and can incoorpora	ate feedback into	their work.
Autonomy	The students can ref	flect their knowledge	and document the results of th	eir work. They can	present the resu	Its in an appropria
	manner.					
Workload in Hours	Independent Study T	Fime 110, Study Time i	n Lecture 70			
Credit points						
Course achievement	Compulsory Bonus	Form	Description			
course achievement	Yes 10 %	Written elaboration				
	Yes 10 %	Presentation				
Examination	Written exam					
Examination duration and	90 minutes					
scale						
	Computer Science: S	Specialisation II. Intellio	jence Engineering: Elective Com	nulsory		
•			cal Technology: Elective Compu			
r bhownig curricula	-	•	g: Specialisation II. Electrical Eng		Compulsory	
	_		g: Specialisation II. Process Engi			Compulsony
					Indiogy. Elective	compaisory
			sterns and hobotics. Elective co	inpuisory		
	Mechatronics: Specia		ficial Organs and Regenerative	Medicine: Elective (Compulsory	
	Mechatronics: Specia Biomedical Engineer	ring: Specialisation Arti	ficial Organs and Regenerative		Compulsory	
	Mechatronics: Specia Biomedical Engineeri Biomedical Engineeri	ring: Specialisation Arti ring: Specialisation Imp	lants and Endoprostheses: Elec	tive Compulsory		
	Mechatronics: Specia Biomedical Engineer Biomedical Engineer Biomedical Engineer	ring: Specialisation Arti ring: Specialisation Imp ring: Specialisation Med	lants and Endoprostheses: Elec	tive Compulsory eory: Elective Com	pulsory	
	Mechatronics: Specia Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri	ing: Specialisation Arti ing: Specialisation Imp ing: Specialisation Me ing: Specialisation Ma	lants and Endoprostheses: Elec dical Technology and Control Th nagement and Business Adminis	tive Compulsory eory: Elective Com stration: Elective Co	pulsory	
	Mechatronics: Specia Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Product Developmen	ing: Specialisation Arti ing: Specialisation Imp ing: Specialisation Me ing: Specialisation Ma nt, Materials and Produ	lants and Endoprostheses: Elec dical Technology and Control Th nagement and Business Adminis ction: Specialisation Product De	tive Compulsory eory: Elective Comp stration: Elective Co velopment: Elective	pulsory ompulsory e Compulsory	
	Mechatronics: Specia Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Product Developmen Product Developmen	ing: Specialisation Arti ring: Specialisation Imp ring: Specialisation Mea ring: Specialisation Mai nt, Materials and Produ nt, Materials and Produ	lants and Endoprostheses: Elec dical Technology and Control Th nagement and Business Adminis ction: Specialisation Product De ction: Specialisation Production	tive Compulsory eory: Elective Com stration: Elective Co velopment: Elective : Elective Compulso	pulsory ompulsory e Compulsory ory	
	Mechatronics: Specia Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Product Developmen Product Developmen Product Developmen	ing: Specialisation Arti ring: Specialisation Imp ring: Specialisation Mea ring: Specialisation Maa nt, Materials and Produ nt, Materials and Produ nt, Materials and Produ	lants and Endoprostheses: Elec dical Technology and Control Th nagement and Business Adminis ction: Specialisation Product De	tive Compulsory eory: Elective Com stration: Elective Co velopment: Elective : Elective Compulso Elective Compulso	pulsory ompulsory e Compulsory ory	

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

urse L0338: Robotics and Navigation in Medicine		
Тур	Project Seminar	
Hrs/wk	2	
СР	2	
Workload in Hours	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	
CP	1	
Workload in Hours	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 M0721: Air Co	Conditioning			
Courses				
Title	Typ Hrs/	wk	СР	
Air Conditioning (L0594)	Lecture 3	WK	5	
Air Conditioning (L0595)	Recitation Section (large) 1		1	
Module Responsible	e NN			
Admission Requirements	s None			
Recommended Previous	s Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer			
Knowledge	e			
Educational Objectives	s After taking part successfully, students have reached the following learning results			
Professional Competence	e			
Knowledge	e Students know the different kinds of air conditioning systems for buildings and mobile applications a controlled. They are familiar with the change of state of humid air and are able to draw the state charter are able to calculate the minimum airflow needed for hygienic conditions in rooms and can choos the basic flow pattern in rooms and are able to calculate the air velocity in rooms with the help of simp principles to calculate an air duct network. They know the different possibilities to produce cold a processes into suitable thermodynamic diagrams. They know the criteria for the assessment of refriger.	anges in a se suitable f ple method and are abl	h1+x,x-diagra ilters. They know s. They know t	
Skills	Students are able to configure air condition systems for buildings and mobile applications. They are able to calculate an air du network and have the ability to perform simple planning tasks, regarding natural heat sources and heat sinks. They can transfor research knowledge into practice. They are able to perform scientific work in the field of air conditioning.			
Personal Competence Social Competence	e e The students are able to discuss in small groups and develop an approach.			
Autonomy	y Students are able to define independently tasks, to get new knowledge from existing knowledge as we knowledge in practice.	ell as to finc	l ways to use tl	
Workload in Hours	s Independent Study Time 124, Study Time in Lecture 56			
Credit points	s 6			
Course achievement	t None			
Examination	n Written exam			
Examination duration and	d 60 min			
scale	e			
Assignment for the	e Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective	Compulsor	У	
Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory			
	Energy Systems: Specialisation Marine Engineering: Elective Compulsory			
	International Management and Engineering: Specialisation II. Energy and Environmental Engineering: E	lective Con	npulsory	
	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			

Тур	Lecture
Hrs/wk	3
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	
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
	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	 Schmitz, G.: Klimaanlagen, Skript zur Vorlesung VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 Recknagel, H.; Sprenger, E.; Schrammek, ER.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflag Deutscher Industrieverlag, 2013

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

<u> </u>					
Courses					
Title			Тур	Hrs/wk	СР
Combined Heat and Power and Cor Combined Heat and Power and Cor			Lecture Recitation Section (large)	3 1	5 1
	Dr. Kristin Abel-Günther		Rectation Section (large)	1	1
•					
Admission Requirements Recommended Previous	None				
Knowledge	 "Gas-Steam Power Plants" 				
	 "Technical Thermodynamics I and 	11"			
	"Heat Transfer"				
	 "Fluid Mechanics" 				
Educational Objectives	After taking part successfully, students h	ave reached the followir	ng learning results		
Professional Competence					
Knowledge	The students outline the thermodynam	ic and chemical funda	mentals of combustion pro	cesses. From th	e knowledge of t
	characteristics and reaction kinetics of	various fuels they can	describe the behaviour of	premixed flame	s and non-premix
	flames, in order to describe the funda				
	furthermore able to describe the form	ation of NO _x and the	primary NO _x reduction mea	asures, and eva	luate the impact
	regulations and allowable limit levels.				
	The students present the layout, design	and operation of Combi	ned Heat and Power plants a	and are in a posit	tion to compare w
	each other district heating plants with	back-pressure steam tu	urbine or condensing turbing	e with pressure-	controlled extract
	tapping, CHP plants with gas turbine or	with combined steam	and gas turbine, or even di	strict heating pla	ants with an inter
	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 the	nis specialised knowledg	ge they are able to evaluate	the ecological si	gnificance of dist
	CHP generation, as well as its economics				
Skills	Using thermodynamic calculations and o	considering the reaction	h kinetics the students will b	e able to detern	nine interdisciplin
	correlations between thermodynamic and chemical processes during combustion. This then enables quantitative analysis of the				
	combustion of gaseous, liquid and solid f	uels and determination	of the quantities and concer	ntrations of the e	xhaust gases. In t
	module the first step toward the utilisat	ion of an energy source	e (combustion) to provide us	sable energy (ele	ectricity and heat
	taught. An understanding of both proced				
	the praxis, such as the CHP energy sup			etwork of Hamb	urg will be used,
	highlight the potential from electricity ge	neration plants with sim	ultaneous heat extraction.		
	Within the framework of the exercises t	he students will first lea	arn to calculate the energet	ic and mass bala	ances of combust
	processes. Moreover, the students will g	ain a deeper understar	nding of the combustion pro	cesses by the ca	lculation of react
	kinetics.				
Personal Competence					
Social Competence	Especially during the exercises the focus	is placed on communic	ation with the tutor. This ani	mates the studer	nts to reflect on th
	existing knowledge and ask specific ques	tions for improving furth	ner this knowledge level.		
Autonomy	The students assisted by the tutors will	be able to perform esti	imating calculations. In this	manner the theo	pretical and practi
, lacenenty	knowledge from the lecture is consolidat				
	highlighted.			5	
Weddeed in Using	Juden en dent Chudu Time 124. Chudu Time	in Lastina FC			
Workload in Hours Credit points	Independent Study Time 124, Study Time				
Course achievement	Compulsory Bonus Form	Description			
area admost and the	No 10 % Written elaboration	-	er Vorlesung wird schriftlich	eine zu auswerte	nde Kurzfrage (5-
		min) zu der V	orlesung der Vorwoche gest	ellt. In den Kurzfr	agen werden klei
		Rechenaufgal	ben, Skizzen oder auch kleine	e Freitexte zur Be	antwortung geste
Examination	Written exam				
Examination duration and	120 min				
scale					
-	Energy Systems: Specialisation Energy Systems				
Following Curricula	Energy Systems: Specialisation Marine Er				
	Energy Systems: Specialisation Energy Systems: International Management and Engineeri			eering: Elective	Compulsory
	meenational management and Engineen	ng. specialisation II. Elle	and Environmental Engli	iccring. Liecuve	compaisory

Course L0216: Combined Hea	at and Power and Combustion Technology
Тур	Lecture
Hrs/wk	3
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Dr. Kristin Abel-Günther
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 _x reduction
Literature	Bezüglich des Themenbereichs "Kraft-Wärme-Kopplung":
	W. Piller, M. Rudolph: Kraft-Wärme-Kopplung, VWEW Verlag
	Kehlhofer, Kunze, Lehmann, Schüller: Handbuch Energie, Band 7, Technischer Verlag Resch
	W. Suttor: Praxis Kraft-Wärme-Kopplung, C.F. Müller Verlag
	K.W. Schmitz, G. Koch: Kraft-Wärme-Kopplung, VDI Verlag
	KH. Suttor, W. Suttor: Die KWK Fibel, Resch Verlag
	und für die Grundlagen der "Verbrennungstechnik":
	 J. Warnatz, U. Maas, R.W. Dibble; Technische Verbrennung: physikalisch-chemische Grundlagen, Modellbildung Schadstoffentstehung. Springer, Berlin [u. a.], 2001

Course L0220: Combined Heat and Power and Combustion Technology	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Kristin Abel-Günther
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Courses				
Title		Тур	Hrs/wk	СР
Energy Meteorology (L0016)		Lecture	1	1
Energy Meteorology (L0017)		Recitation Section (small)	1	1
Collector Technology (L0018)		Lecture	2	2
Solar Power Generation (L0015)		Lecture	2	2
Module Responsible	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended Previous	none			
Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Knowledge	With the completion of this module, stud	ents will be able to deal with technical foundation	s and current issues	s and problems in
	field of solar energy and explain and eva	aulate these critically in consideration of the pric	or curriculum and cu	irrent subject spec
	issues. In particular they can profession	onally describe the processes within a solar c	ell and explain the	specific features
	application of solar modules. Furthermore	e, they can provide an overview of the collector t	echnology in solar tł	nermal systems.
Skills		tical foundations of exemplary energy systems		
		potential and constraints of solar energy system		
		n solar energy systems in consideration of technic		
		ents can evalute the economic and ecologic cond	litions of these syst	ems. They can se
	calculation methods within the radiation	theory for these topics.		
Personal Competence				
Social Competence	Students are able to discuss issues in the	e thematic fields in the renewable energy sector a	iddressed within the	module.
Autonomy	Students can independently exploit source	ces and acquire the particular knowledge about t	he subject area with	respect to empha
2		assistance of lecturers, they can discrete use		
		ased on this procedure they can concrete asse		, ,
	consequently define the further workflow			
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	3 hours written exam			
scale				
Assignment for the	Energy and Environmental Engineering: 9	Specialisation Energy and Environmental Enginee	ring: Elective Comp	ulsory
Following Curricula	Energy Systems: Specialisation Energy S	ystems: Elective Compulsory		
	International Management and Engineeri	ing: Specialisation II. Renewable Energy: Elective	Compulsory	
	International Management and Engineeri	ing: Specialisation II. Energy and Environmental E	ngineering: Elective	Compulsory
	Renewable Energies: Core qualification: (Compulsory		
	Theoretical Mechanical Engineering: Spe	cialisation Energy Systems: Elective Compulsory		
	Theoretical Mechanical Engineering: Tech	hnical Complementary Course: Elective Compulso	ry	

Course L0016: Energy Meteorology		
Тур	Lecture	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Volker Matthias, Dr. Beate Geyer	
Language	DE	
Cycle	SoSe	
Content		
Literature	 Helmut Kraus: Die Atmosphäre der Erde Hans Häckel: Meteorologie Grant W. Petty: A First Course in Atmosheric Radiation Martin Kaltschmitt, Wolfgang Streicher, Andreas Wiese: Renewable Energy Alexander Löw, Volker Matthias: Skript Optik Strahlung Fernerkundung 	

Course L0017: Energy Meteo	ourse L0017: Energy Meteorology	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	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: Collector Tech	nology
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Agis Papadopoulos
Language	DE
Cycle	SoSe
Content	 Introduction: Energy demand and application of solar energy. Heat transfer in the solar thermal energy: conduction, convection, radiation. Collectors: Types, structure, efficiency, dimensioning, concentrated systems. Energy storage: Requirements, types. Passive solar energy: components and systems. Solar thermal low temperature systems: collector variants, construction, calculation. Solar thermal high temperature systems: Classification of solar power plants construction. Solar air conditioning.
Literature	 Vorlesungsskript. Kaltschmitt, Streicher und Wiese (Hrsg.). Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, 5. Auflage, Springer, 2013. Stieglitz und Heinzel .Thermische Solarenergie: Grundlagen, Technologie, Anwendungen. Springer, 2012. Von Böckh und Wetzel. Wärmeübertragung: Grundlagen und Praxis, Springer, 2011. Baehr und Stephan. Wärme- und Stoffübertragung. Springer, 2009. de Vos. Thermodynamics of solar energy conversion. Wiley-VCH, 2008. Mohr, Svoboda und Unger. Praxis solarthermischer Kraftwerke. Springer, 1999.

Course L0015: Solar Power G	Generation
	Lecture
Hrs/wk	
CP	
	2 Independent Study Time 32, Study Time in Lecture 28
	Martin Schlecht, Prof. Alf Mews, Roman Fritsches, Paola Pignatelli
Language	
Cycle	
Content	Photovoltaics:
	1. Introduction
	2. Primary energies and consumption, available solar energy
	3. Physics of the ideal solar cell
	4. Light absorption, PN transition, characteristic sizes of the solar cell, efficiency
	5. Physics of the real solar cell
	6. Charge carrier recombination, characteristic curves, barrier layer recombination, equivalent circuit diagram
	7. Increasing efficiency
	8. Methods for increasing the quantum yield and reducing recombination
	9. Hetero- and tandem structures
	10. Heterojunction, Schottky, electrochemical, MIS and SIS cell, tandem cell
	11. Concentrator cells
	12. Concentrator optics and tracking systems, concentrator cells
	13. Technology and properties: solar cell types, manufacturing, monocrystalline silicon and gallium arsenide, polycrystalline
	silicon and silicon thin film cells, thin film cells on carriers (amorphous silicon, CIS, electrochemical cells)
	14. Modules
	15. Switches
	Concentrating solar power plants:
	1. Introduction
	2. Point focused technologies
	3. Line focused technologies
	4. Design of CSP projects
Literature	
	A. Götzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik, Teubner Studienskripten, Stuttgart, 1995
	• A. Götzberger: Sonnenenergie: Photovoltaik : Physik und Technologie der Solarzelle, Teubner Stuttgart, 1994
	HJ. Lewerenz, H. Jungblut: Photovoltaik, Springer, Berlin, Heidelberg, New York, 1995
	A. Götzberger: Photovoltaic solar energy generation, Springer, Berlin, 2005
	C. Hu, R. M. White: Solar Cells, Mc Graw Hill, New York, 1983
	HG. Wagemann: Grundlagen der photovoltaischen Energiewandlung: Solarstrahlung, Halbleitereigenschaften und
	Solarzellenkonzepte, Teubner, Stuttgart, 1994
	R. J. van Overstraeten, R.P. Mertens: Physics, technology and use of photovoltaics, Adam Hilger Ltd, Bristol and Boston,
	1986
	• B. O. Seraphin: Solar energy conversion Topics of applied physics V 01 31, Springer, Berlin, Heidelberg, New York, 1995
	P. Würfel: Physics of Solar cells, Principles and new concepts, Wiley-VCH, Weinheim 2005
	U. Rindelhardt: Photovoltaische Stromversorgung, Teubner-Reihe Umwelt, Stuttgart 2001
	V. Quaschning: Regenerative Energiesysteme, Hanser, München, 2003
	G. Schmitz: Regenerative Energien, Ringvorlesung TU Hamburg-Harburg 1994/95, Institut für Energietechnik

Module M0771: Flight	Physics			
-				
Courses				
Title		Тур	Hrs/wk	СР
Aerodynamics and Flight Mechanics	s I (L0727)	Lecture	3	3
Flight Mechanics II (L0730)		Lecture	2	2
Flight Mechanics II (L0731)		Recitation Section (large)	1	1
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge	Mathematics			
	Machematics Mechanics			
	Mechanics Thermodynamics			
	Aviation			
	• Aviation			
Educational Objectives	After taking part successfully, students I	nave reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 96, Study Time	n Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 Minutes (WS) + 90 Minutes (SS)			
scale				
Assignment for the	Aircraft Systems Engineering: Core qual	ification: Compulsory		
Following Curricula	International Management and Engineer	ing: Specialisation II. Aviation Systems: Elective Co	mpulsory	
	Product Development, Materials and Pro	duction: Specialisation Product Development: Elect	ive Compulsory	
	Product Development, Materials and Pro	duction: Specialisation Production: Elective Compul	sory	
	Product Development, Materials and Pro	duction: Specialisation Materials: Elective Compulse	ory	
	Theoretical Mechanical Engineering: Spe	ecialisation Aircraft Systems Engineering: Elective C	ompulsory	
	Theoretical Mechanical Engineering: Teo	hnical Complementary Course: Elective Compulsor	y	

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

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

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

Module M0764: Fligh				
Courses				
Title		Тур	Hrs/wk	СР
Flight Control Systems (L0736)		Lecture	3	4
Flight Control Systems (L0740)		Recitation Section (large)	2	2
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None			
Recommended Previous	basic knowledge of:			
Knowledge	mathematics			
	mechanics			
	thermo dynamics			
	electronics			
	fluid technology			
	control technology			
Educational Objectives	After taking part successfully, students have re	ached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	- describe the structure of mineral flights		high lift such as	·
	 describe the structure of primary flight control systems as well as actuation-, avionic-, high lift systems in general along with corresponding properties and applications. 			
	corresponding properties and application			
	explain different configurations and des	igns and their origins		
	•			
Skills	Students are able to			
	 size primary flight control actuation syst 	ems		
	 perform a controller design process for t 			
	 design high-lift kinematics 			
Personal Competence				
	Students are able to:			
···· , ···				
	Develop joint solutions in mixed teams			
Autonomy	Students are able to:			
		priate yet simplified design processes for airc	raft systems from	n complex issues ar
	circumstances in a self-reliant manner			
Workload in Hours	Independent Study Time 110, Study Time in Le	cture 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	165 Minutes			
scale				
-	Aircraft Systems Engineering: Core qualification			
Following Curricula		•		
	Product Development, Materials and Production			
	Product Development, Materials and Production			
	Product Development, Materials and Production		У	
	Theoretical Mechanical Engineering: Technical		mulcon	
	Theoretical Mechanical Engineering: Specialisa	tion Antrait Systems Engineering: Elective Co	mpulsory	

Course L0736: Flight Control	Systems
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Frank Thielecke
Language	DE
Cycle	SoSe
Content	 Actuation (Principles of actuators; electro-mechanical actuators; modeling, analysis and sizing of position control systems; hydro-mechanic actuation systems) 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) 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) Fuel Systems (Architectures; aviation fuels; system components; fueling system; tank inerting system; fuel management; trim tank) De- and Anti-Ice Systems: (Atmospheric icing conditions; principles of de- and anti-ice systems)
Literature	 Moir, Seabridge: Aircraft Systems Torenbek: Synthesis of Subsonic Airplane Design Curry: Aircraft Landing Gear Design: Principles and Practices

Course L0740: Flight Control	ourse L0740: Flight Control Systems		
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	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title	Ту	ур	Hrs/wk	СР
Harbour Engineering (L0809)		ecture	2	2
Harbour Engineering (L1414)		oject-/problem-based Learning	1	2
Port Planning and Port Constructior		ecture	2	2
Module Responsible	Prof. Peter Fröhle			
Admission Requirements	None			
Recommended Previous	Basics of coastal engineering			
Knowledge				
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 functional design of a port and apply the			rt and apply them
	design tasks. They can design the fundamental elements of a port.			
Chille	The students are able to select and apply appropriate approaches for the functional design of ports.			
SKIIIS	The students are able to select and apply appropriate approaches it	or the functional design of por	15.	
Personal Competence				
Social Competence	tence The students are able to deploy their gained knowledge in applied problems such as the functional design of ports. Additional they will be able to work in team with engineers of other disciplines.			of ports. Additiona
Autonomy	The students will be able to independently extend their knowledge a	and apply it to new problems.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	The duration of the examination is 150 min. The examination inc	cludes tasks with respect to	the general u	inderstanding of
scale	lecture contents and calculations tasks.			
Assignment for the	Civil Engineering: Specialisation Structural Engineering: Elective Cor	mpulsory		
Following Curricula	Civil Engineering: Specialisation Geotechnical Engineering: Elective	Compulsory		
	Civil Engineering: Specialisation Coastal Engineering: Compulsory			
	Civil Engineering: Specialisation Water and Traffic: Elective Compuls	sory		
	International Management and Engineering: Specialisation II. Civil E	ingineering: Elective Compulse	ory	
	Theoretical Mechanical Engineering: Technical Complementary Cour	rse: Elective Compulsory		

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

Course L1414: Harbour Engin	urse L1414: Harbour Engineering		
Тур	Project-/problem-based Learning		
Hrs/wk	1		
СР	2		
Workload in Hours	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	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Frank Feindt	
Language	DE	
Cycle	SoSe	
Content	 SoSe Planning and implementation of major projects Market analysis and traffic relations Planning process and plan Port planning in urban neighborhood Development of the logistics center "Port of Hamburg" in the metropolis Quays and waterfront structure Special planning Law Harbor - securing of a flexible use of the port Dimensioning of quays Flood protection structures Port of Hamburg - Infrastructure and development Preparation of areas Scour formation in front of shore structures 	
Literature	Vorlesungsumdruck, s. www.tu-harburg.de/gbt	

Courses				
Title		Тур	Hrs/wk	СР
Port Logistics (L0686)		Lecture	2	3
Port Logistics (L1473)		Recitation Section (small)	2	3
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge	none			
Educational Objectives	After taking part successfully, students have reached the follow	ing learning results		
Professional Competence	Aren taking part successiony, students have reached the follow			
Knowledge	Th			
	After completing the module, students can			
	 reflect on the development of seaports (in terms of the functions of the ports and the corresponding terminals, as relevant operator models) and place them in their historical context; explain and evaluate different types of seaport terminals and their specific characteristics (cargo, tratechnologies, logistic functional areas); analyze common planning tasks (e.g. berth planning, stowage planning, yard planning) at seaport terminals a suitable approaches (in terms of methods and tools) to solve these planning tasks; identify future developments and trends regarding the planning and control of innovative seaport terminals a them in a problem-oriented manner. 			cargo, transhipme erminals and devel
Skills	 After completing the module, students will be able to recognize functional areas in ports and seaport terminals; define and evaluate suitable operating systems for container terminals; perform static calculations with regard to given boundary conditions, e.g. required capacity (parking spaces, equipme requirements, quay wall length, port access) on selected terminal types; reliably estimate which boundary conditions influence common logistics indicators in the static planning of selected termir types and to what extent. 			
Personal Competence Social Competence	After completing the module, students can • transfer the acquired knowledge to further questions of p • discuss and successfully organize extensive task package • in small groups, document work results in writing in an ur	es in small groups;	nt them to an ap	propriate extent.
Autonomy	 After completing the module, the students are able to research and select specialist literature, including standards, guidelines and journal papers, and to develop the con independently; submit own parts in an extensive written elaboration in small groups in due time and to present them jointly within a time frame. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Description			
	No 15 % Written elaboration			
Examination	Written exam			
Examination duration and	120 minutes			
scale	Civil Engineering: Specialization Constal Engineering Station	empulson		
Assignment for the	Civil Engineering: Specialisation Coastal Engineering: Elective C			
Following Curricula	International Management and Engineering: Specialisation II. Lo Logistics, Infrastructure and Mobility: Specialisation Production a		sorv	
	Logistics, Infrastructure and Mobility: Specialisation Production a	÷ ,	-	
	Renewable Energies: Specialisation Wind Energy Systems: Elect			
	Naval Architecture and Ocean Engineering: Core qualification: E			
	Theoretical Mechanical Engineering: Specialisation Maritime Tec			
	Theoretical Mechanical Engineering: Technical Complementary	Course: Elective Compulsory		

Course L0686: Port 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 technical equipment used • Handling of current issues in port logistics
Literature	 Alderton, Patrick (2013). Port Management and Operations. Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium. Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005. Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen. Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele. Jahn, Carlos; Saxe, Sebastian (Hg.). Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag, 2017. Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft Lun, Y.H.V. and Lai, KH. and Cheng, T.C.E. (2010). Shipping and Logistics Management. Woitschützke, Claus-Peter (2013). Verkehrsgeografie.

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	 Alderton, Patrick (2013). Port Management and Operations. Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium. Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. (2005) Berlin Heidelberg: Springer-Verlag. Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen. Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele. Jahn, Carlos; Saxe, Sebastian (Hg.) (2017) Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag. Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft Lun, Y.H.V. and Lai, KH. and Cheng, T.C.E. (2010). Shipping and Logistics Management. Woitschützke, Claus-Peter (2013). Verkehrsgeografie.

Courses				
		-		
Title Marine Geotechnics (L0548)		Typ Lecture	Hrs/wk	СР 2
Marine Geotechnics (L0549)		Recitation Section (large)	2	2
Steel Structures in Foundation and	Hydraulic Engineering (L1146)	Lecture	2	2
Module Responsible	Prof. Jürgen Grabe			
Admission Requirements				
Recommended Previous	complete modules: Geotechnics I-III, Mathe	ematics I-III		
Knowledge				
	courses: Soil laboratory course			
Educational Objectives	After taking part successfully, students have	ve reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 110, Study Time i	in Lecture 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Civil Engineering: Specialisation Geotechni	cal Engineering: Compulsory		
Following Curricula	Civil Engineering: Specialisation Structural	Engineering: Elective Compulsory		
	Civil Engineering: Specialisation Coastal En	ngineering: Compulsory		
	Theoretical Mechanical Engineering: Specia	alisation Maritime Technology: Elective Compulsor	/	
		ical Complementary Course: Elective Compulsory		
	Water and Environmental Engineering: Spe			
	• • •	ecialisation Environment: Elective Compulsory		
	Water and Environmental Engineering: Spe	ecialisation Water: Elective Compulsory		

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

Course L0549: Marine Geote	urse L0549: Marine Geotechnics	
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	2	
Workload in Hours	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 Structur	Course L1146: Steel Structures in Foundation and Hydraulic Engineering	
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Frank Feindt	
Language	DE	
Cycle	SoSe	
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		Тур	Hrs/wk	СР
Maritime Transport (L0063)		Lecture	2	3
Maritime Transport (L0064)		Recitation Section (small)	2	3
Module Responsible	Prof. Carlos Jahn			
•	None			
Recommended Previous				
Knowledge				
	After taking part successfully, students have n	eached the following learning results		
Professional Competence				
Knowledge	The students are able to			
	 present the actors involved in the marit 	ime transport chain with regard to their typic	al tasks;	
	 name common cargo types in shipping 	and classify cargo to the corresponding categ	ories;	
	 explain operating forms in maritime shi 	pping, transport options and management in	transport networks	;
	 weigh the advantages and disadvantag 	es of the various modes of hinterland transpo	rt and apply them i	n practice;
	 present relevant factors for the location 	n planning of ports and seaport terminals a	nd discuss them ir	n a problem-orien
	way;			
	estimate the potential of digitisation in	maritime shipping.		
Skills	The students are able to			
SKIIS				
		s and functions of the actors in the maritime s		
		ort chain and recommend appropriate propos		
		se material and information flows of a mai	ritime logistics cha	ain, identify poss
	problems and recommend solutions;	cuptions to the supply shain.		
	 perform risk assessments of human disk analyse accidents in the field of maritim 	ne logistics and evaluating their relevance in e	weryday life:	
		field of maritime logistics in a differentiated v		
		ods in a hitherto unknown field of activity and		spective advantad
		···· · · · · · · · · · · · · · · · · ·		
Personal Competence				
Social Competence	The students are able to			
	 discuss and organise extensive work pa 	ckages in groups;		
	 document and present the elaborated r 			
Autonomy	The students are capable to			
	 research and select technical literature, 	including standards and guidelines;		
	 submit own shares in an extensive writt 	en elaboration in small groups in due time.		
Westland in House	Indexeduate Churche Time 124, Churche Time in L			
	Independent Study Time 124, Study Time in L	oc ure of		
•	6 Compulsory Bonus Form	Description		
Course achievement	No 15 % Subject theoretical	andTeilnahme an einem Planspiel und ansch	nließende schriftlich	ne Ausarbeituna
	practical work			5
Examination	Written exam			
Examination duration and	120 minutes			
scale	Civil Engineering: Specialization Constal Finite	poring: Elective Computerny		
-	Civil Engineering: Specialisation Coastal Engin	· · ·		
Following Curricula	International Management and Engineering: S Logistics, Infrastructure and Mobility: Specialis			
	Logistics, Infrastructure and Mobility: Specialis			
	Renewable Energies: Specialisation Wind Ener			
	Theoretical Mechanical Engineering: Specialisation		iry	
	Theoretical Mechanical Engineering: Technical			

Course L0063: Maritime Trar	isport	
Тур	Lecture	
Hrs/wk		
СР	3	
Workload in Hours	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	 Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005. Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009. Stopford, Martin. Maritime Economics Routledge, 2009 	

Course L0064: Maritime Tran	Course L0064: Maritime Transport		
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 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	 Stopford, Martin. Maritime Economics Routledge, 2009 Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005. Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009. 		

Module M1021: Marin	e Diesel Engine Plants			
Courses				
Title		Тур	Hrs/wk	СР
Marine Diesel Engine Plants (L0637		Lecture	3	4
Marine Diesel Engine Plants (L0638	3)	Recitation Section (large)	1	2
Module Responsible	Prof. Christopher Friedrich Wirz			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have re	ached the following learning results		
Professional Competence				
Knowledge	Students can			
	• explain different types four / two-stroke engi	nes and assign types to given engines,		
	 name definitions and characteristics, as well 	as		
	 elaborate on special features of the heavy oil 	operation lubrication and cooling		
CI-:!!-		operation, rapression and coornig.		
SKIIIS	Students can			
	• evaluate the interaction of ship, engine and p	propeller,		
	• use relationships between gas exchange, flus	hing, air demand, charge injection and combu	stion for the desi	gn of systems,
	• design waste heat recovery, starting systems	, controls, automation, foundation and design	machinery space	es , and
	apply evaluation methods for excited motor r	noise and vibration.		
Personal Competence				
Social Competence	The students are able to communicate and c industry.	ooperate in a professional environment in the	e shipbuilding ar	nd component supp
Autonomy	The widespread scope of gained knowledge er confidently.	ables the students to handle situations in thei	r future professio	on independently a
Workload in Hours	Independent Study Time 124, Study Time in Le	cture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Energy Systems: Specialisation Energy System	s: Elective Compulsory		
Following Curricula	Energy Systems: Specialisation Marine Enginee	ering: Compulsory		
	Naval Architecture and Ocean Engineering: Con	e qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical	Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisa	tion Maritime Technology: Elective Compulsory	1	

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	 Historischer Überblick Bauarten von Vier- und Zweitaktmotoren als Schiffsmotoren Vergleichsprozesse, Definitionen, Kenndaten Zusammenwirken von Schiff, Motor und Propeller Ausgeführte Schiffsdieselmotoren Gaswechsel, Spülverfahren, Luftbedarf Aufladung von Schiffsdieselmotoren Einspritzung und Verbrennung Schwerölbetrieb Schmierung Kühlung Wärmebilanz Abwärmenutzung Anlassen und Umsteuern Regelung, Automatisierung, Überwachung Motorerregte Geräusche und Schwingungen Fundamentierung Gestaltung von Maschinenräumen
Literature	- D. Washingdi Davidan's Marina Diagol Fasinga
	 D. Woodyard: Pounder's Marine Diesel Engines H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik K. Kuiken: Diesel Engines Mollenhauer, Tschöke: Handbuch Dieselmotoren Projektierungsunterlagen der Motorenhersteller

Course L0638: Marine Diesel	ourse L0638: Marine Diesel Engine Plants	
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	2	
Workload in Hours	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	

Courses Title Approximation and Stability (L0487) Approximation and Stability (L0488) Module Responsible Prof. Marko Lindner Admission Requirements None Recommended Previous Knowledge Linear Algebra: systems of linear equations, least squai Analysis: sequences, series, differentiation, integration Educational Objectives After taking part successfully, students have reached the folic Professional Competence Knowledge Students are able to sketch and interrelate basic concepts of functional anal name and understand concrete approximation method: name and explain basic stability theorems, discuss spectral quantities, conditions numbers and me Skills Students are able to apply approximation methods, apply stability theorems, compute spectral quantities, apply regularisation methods. 		Hrs/wk 3 1	CP 4 2		
Approximation and Stability (L0487) Approximation and Stability (L0488) Module Responsible Prof. Marko Lindner Admission Requirements None Recommended Previous Knowledge Linear Algebra: systems of linear equations, least square Analysis: sequences, series, differentiation, integration Educational Objectives After taking part successfully, students have reached the folloc Professional Competence Students are able to sketch and interrelate basic concepts of functional anal name and understand concrete approximation methods name and explain basic stability theorems, discuss spectral quantities, conditions numbers and methods, apply approximation methods, apply stability theorems, compute spectral quantities, 	Lecture Recitation Section (small) res problems, eigenvalues, singu	3	4		
Approximation and Stability (L0488) Module Responsible Prof. Marko Lindner Admission Requirements None Recommended Previous Knowledge Linear Algebra: systems of linear equations, least square Analysis: sequences, series, differentiation, integration Educational Objectives After taking part successfully, students have reached the folic Professional Competence Knowledge Students are able to Students are and understand concrete approximation methods name and explain basic stability theorems, discuss spectral quantities, conditions numbers and methods, apply approximation methods, apply stability theorems, compute spectral quantities,	Recitation Section (small)	1			
Module Responsible Prof. Marko Lindner Admission Requirements None Recommended Previous Knowledge Linear Algebra: systems of linear equations, least square • Analysis: sequences, series, differentiation, integration Educational Objectives After taking part successfully, students have reached the follor Professional Competence Knowledge Students are able to Students are and understand concrete approximation methods • name and understand concrete approximation methods • name and explain basic stability theorems, • discuss spectral quantities, conditions numbers and methods, • apply approximation methods, • apply stability theorems, • compute spectral quantities,	res problems, eigenvalues, singu	ılar values			
Admission Requirements None Recommended Previous Knowledge Linear Algebra: systems of linear equations, least squal Analysis: sequences, series, differentiation, integration Educational Objectives After taking part successfully, students have reached the folic Professional Competence Knowledge Students are able to sketch and interrelate basic concepts of functional anal name and understand concrete approximation method: name and explain basic stability theorems, discuss spectral quantities, conditions numbers and methods, apply basic results from functional analysis, apply stability theorems, compute spectral quantities, 		ılar values			
Knowledge • Linear Algebra: systems of linear equations, least square • Analysis: sequences, series, differentiation, integration Educational Objectives After taking part successfully, students have reached the folic Professional Competence Students are able to Knowledge Students are able to • sketch and interrelate basic concepts of functional anal • name and understand concrete approximation methods • name and explain basic stability theorems, • discuss spectral quantities, conditions numbers and methods, • apply basic results from functional analysis, • apply stability theorems, • compute spectral quantities,		ılar values			
Educational Objectives After taking part successfully, students have reached the folic Professional Competence Students are able to Knowledge Students are able to • sketch and interrelate basic concepts of functional anal • name and understand concrete approximation method: • name and explain basic stability theorems, • discuss spectral quantities, conditions numbers and method: Skills Students are able to • apply basic results from functional analysis, • apply approximation methods, • apply stability theorems, • compute spectral quantities,					
Professional Competence Students are able to Knowledge Students are able to sketch and interrelate basic concepts of functional anal name and understand concrete approximation method: name and explain basic stability theorems, discuss spectral quantities, conditions numbers and me Skills Students are able to apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities,	wing learning results				
Knowledge Students are able to sketch and interrelate basic concepts of functional anal name and understand concrete approximation methods name and explain basic stability theorems, discuss spectral quantities, conditions numbers and me Skills Students are able to apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities,		After taking part successfully, students have reached the following learning results			
 sketch and interrelate basic concepts of functional anal name and understand concrete approximation method: name and explain basic stability theorems, discuss spectral quantities, conditions numbers and methods Students are able to apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities, 					
 name and understand concrete approximation method: name and explain basic stability theorems, discuss spectral quantities, conditions numbers and methods Students are able to apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities, 					
 name and explain basic stability theorems, discuss spectral quantities, conditions numbers and me Skills Students are able to apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities, 	lysis (Hilbert space, operators),				
 discuss spectral quantities, conditions numbers and me Skills Students are able to apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities, 	S,				
 Skills Students are able to apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities, 					
 apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities, 	ethods of regularisation				
 apply approximation methods, apply stability theorems, compute spectral quantities,	kills Students are able to				
apply approximation methods,apply stability theorems,compute spectral quantities,					
 apply stability theorems, compute spectral quantities,					
compute spectral quantities,					
 apply regularisation methods. 					
Personal Competence					
Social Competence Students are able to solve specific problems in groups and to	present their results appropriate	ely (e.g. as a sem	inar presentatior		
 Students are capable of checking their understanding precisely and know where to get help in solving them. 					
 Students have developed sufficient persistence to be problems. 	able to work for longer period:	s in a goal-orient	ed manner on t		
Workload in Hours Independent Study Time 124, Study Time in Lecture 56					
Credit points 6					
Course achievement Compulsory Bonus Form Description					
Yes None Presentation					
Examination Oral exam					
Examination duration and 20 min scale					
Assignment for the Electrical Engineering: Specialisation Control and Power Syste	ms Engineering: Elective Comp	lson			
Following Curricula Mechatronics: Specialisation Intelligent Systems and Robotics		alson y			
Technomathematics: Specialisation I. Mathematics: Elective C					
Theoretical Mechanical Engineering: Technical Complementar					
Theoretical Mechanical Engineering: Technical Complemental Theoretical Mechanical Engineering: Specialisation Robotics a		ampulse			

Course L0487: Approximatio	n and Stability
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	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.
	amension.
	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)
	• regularisation methods (truncated SVD, richonov)
Literature	D. Hagen, C. Bach, P. Silbermann, C* Algebras in Numerical Analysis
	 R. Hagen, S. Roch, B. Silbermann: C*-Algebras in Numerical Analysis H. W. Alt: Lineare Funktionalanalysis
	M. Lindner: Infinite matrices and their finite sections
	- Pr. Envirer, minite matrices and area minite sections

Course L0488: Approximation and Stability		
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	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses				
Title		Тур	Hrs/wk	СР
Fundamentals of High-Performance	e Computing (L0242)	Lecture	2	3
Fundamentals of High-Performance	e Computing (L1416)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Thomas Rung			
Admission Requirements	None			
Recommended Previous Knowledge	 Basic knowledge in usage of moderr Programming skills 	n IT environment		
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	Students are able to outline the fundamentals of numerical algorithms for high-performance computers by reference to moder			
	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				
Social Competence	Students are able to develop and code algo	orithms in a team.		
Autonomy				
Workload in Hours	Independent Study Time 124, Study Time i	in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	1.5h			
scale				
Assignment for the	Naval Architecture and Ocean Engineering	: Core qualification: Elective Compulsory		
Following Curricula	Theoretical Mechanical Engineering: Techn	ical Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specia	alisation Simulation Technology: Elective Compulsory		

Course L0242: Fundamentals	s of High-Performance Computing
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	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	ourse L1416: Fundamentals of High-Performance Computing		
Тур	Project-/problem-based Learning		
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					
Title		Тур	Hrs/wk	СР	
Numerical Algorithms in Structural	Mechanics (L0284)	Lecture	2	3	
Numerical Algorithms in Structural	Mechanics (L0285)	Recitation Section (small)	2	3	
Module Responsible	Prof. Alexander Düster				
Admission Requirements	None				
Recommended Previous	Knowledge of partial differential equations is re	commended.			
Knowledge					
Educational Objectives	After taking part successfully, students have re	ached the following learning results			
Professional Competence					
Knowledge	Students are able to				
	+ give an overview of the standard algorithms	hat 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 compute				
	science background.				
Skille	Students are able to				
JKIIIS	+ construct algorithms for given numerical met	hods			
	+ select for a given problem of structural mech				
	+ apply numerical algorithms to solve problems	•			
	+ implement algorithms in a high-level program				
	+ critically judge and verfiy numerical algorithm				
Personal Competence					
Social Competence	Students are able to				
	+ solve problems in heterogeneous groups and	to document the corresponding results.			
Autonomy	Students are able to				
, aconomy	+ acquire independently knowledge to solve co	mplex problems.			
	·				
Workload in Hours	Independent Study Time 124, Study Time in Lee	ture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	2h				
scale					
Assignment for the	Materials Science: Specialisation Modeling: Elec	tive Compulsory			
Following Curricula	Naval Architecture and Ocean Engineering: Cor	e qualification: Elective Compulsory			
	Technomathematics: Specialisation III. Engineer	ing Science: Elective Compulsory			
	Theoretical Mechanical Engineering: Technical	Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisat	ion Simulation Technology: Elective Compulse	rv		

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

Course L0285: Numerical Alg	rse L0285: Numerical Algorithms in Structural Mechanics		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	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					
Title		Тур	Hrs/wk	СР	
Machine Learning and Data Mining	(L0340)	Lecture	2	4	
Machine Learning and Data Mining		Recitation Section (small)	2	2	
Module Responsible	NN				
Admission Requirements					
Recommended Previous					
Knowledge	Calculus				
-	Stochastics				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results			
Professional Competence					
	Students can explain the difference betwe	een instance-based and model-based learning a	pproaches, and the	, can enumerate ba	
		of the two basic approaches, either on the b			
	÷ ,	g with uncertainty, students can describe suit			
		ers, or structures used in these formalisms car			
		ch different clustering techniques. They depict l			
	can be improved by ensemble learning, and they can summarize how this influences computational learning theory. Algorithms for				
	reinforcement learning can also be explained by students.				
	5 -				
Skills	Student derive decision trees and, in tur	n, propositional rule sets from simple and stat	ic data tables and	are able to name a	
	explain basic optimization techniques. They present and apply the basic idea of first-order inductive leaning. Students apply the				
	BME, MAP, ML, and EM algorithms for learning parameters of Bayesian networks and compare the different algorithms. They also				
	know how to carry out Gaussian mixtu	ire learning. They can contrast kNN classifier	rs, neural networks	s, and support vect	
		ion areas and algorithmic properties. Students			
	and explain the basic components of th	ose techniques. Students compare related ma	chine learning tech	niques, e.g., k-mea	
	clustering and nearest neighbor classifi	cation. They can distinguish various ensembl	e learning techniqu	ues and compare t	
	different goals of those techniques.				
Personal Competence					
Social Competence					
Autonomy					
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 minutes				
scale					
Assignment for the					
Following Curricula		ng: Specialisation II. Information Technology: Ele	ctive Compulsory		
	Mechatronics: Technical Complementary	Course: Elective Compulsory			
	Mechatronics: Specialisation System Desi	gn: Elective Compulsory			
	Mechatronics: Specialisation Intelligent Sy	stems and Robotics: Elective Compulsory			
	Theoretical Mechanical Engineering: Tech	nical Complementary Courses Elective Compuls	00/		
	Theoretical Meenanical Engineering. Teen	flical complementary course. Elective compuls	ory		

Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	SoSe
Content	 Decision trees First-order inductive learning Incremental learning: Version spaces Uncertainty Bayesian networks Learning parameters of Bayesian networks BME, MAP, ML, EM algorithm Learning structures of Bayesian networks Gaussian Mixture Models kNN classifier, neural network classifier, support vector machine (SVM) classifier Clustering Distance measures, k-means clustering, nearest neighbor clustering Kernel Density Estimation Ensemble Learning Reinforcement Learning Computational Learning Theory
Literature	1. Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russel, Peter Norvig, Prentice Hall, 2010, Chapters 13, 1- 18-21
	2. Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press 2012

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

Courses				
Title		Тур	Hrs/wk	СР
Numerical Mathematics II (L0568)		Lecture	2	3
Numerical Mathematics II (L0569)		Recitation Section (small)	2	3
Module Responsible	Prof. Sabine Le Borne			
Admission Requirements	None			
Recommended Previous	Numerical Mathematics I			
Knowledge	Python knowledge			
Educational Objectives	After taking part successfully, students have reache	ed the following learning results		
Professional Competence				
Knowledge	Students are able to			
	 name advanced numerical methods for 	interpolation, approximation integration	n, eigenvalue n	roblems, eigenvali
	problems, nonlinear root finding problems ar		i, eigenvalue p	robients, eigenvar
	 repeat convergence statements for the number 		5,	
	 explain practical aspects of numerical method 			
	 explain aspects regarding the practical imp 			Itational and stora
	complexity.			
Skills	Students are able to			
SKIIIS				
	 implement, apply and compare advanced nu 	merical methods in Python,		
	 justify the convergence behaviour of numeri 	cal methods with respect to the problem a	and solution algo	rithm and to transf
	it to related problems,			
	 for a given problem, develop a suitable so 		omposition of se	everal algorithms,
	execute this approach and to critically evaluated	ate the results		
Personal Competence				
Social Competence	Students are able to			
	 work together in heterogeneously composed 	teams (i.e. teams from different study n	rograms and bac	karound knowledge
	explain theoretical foundations and support			
		call other was practical aspects regarding	g the implemente	cion or argomenins.
Autonomy	Students are capable			
	 to assess whether the supporting theoretical 	and practical excercises are better solver	individually or in	n a team.
	 to assess their individual progess and, if nec 			, a count,
		······································		
	Independent Study Time 124, Study Time in Lecture	e 56		
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and scale	25 min			
Assignment for the	Computer Science: Specialisation III. Mathematics:	Elective Compulson		
Following Curricula	Computer Science: Specialisation III. Mathematics: Computational Science and Engineering: Specialisa			
i onowing curricula	Technomathematics: Specialisation I. Mathematics:			
	Theoretical Mechanical Engineering: Technical Com			
	Theoretical Mechanical Engineering: Core qualificat			

Course L0568: Numerical Mathematics II		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke	
Language	DE/EN	
Cycle	SoSe	
Content	 Error and stability: Notions and estimates Rational interpolation and approximation Multidimensional interpolation (RBF) and approximation (neural nets) Quadrature: Gaussian quadrature, orthogonal polynomials Linear systems: Perturbation theory of decompositions, structured matrices Eigenvalue problems: LR-, QD-, QR-Algorithmus Nonlinear systems of equations: Newton and Quasi-Newton methods, line search (optional) Krylov space methods: Arnoldi-, Lanczos methods (optional) 	
Literature	 Skript Stoer/Bulirsch: Numerische Mathematik 1, Springer Dahmen, Reusken: Numerik f ür Ingenieure und Naturwissenschaftler, Springer 	

Course L0569: Numerical Ma	Course L0569: Numerical Mathematics II	
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, Dr. Jens-Peter Zemke	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses				
Title		Тур	Hrs/wk	СР
Applied Design Methodology in Mee	chatronics (L1523)	Lecture	2	2
Applied Design Methodology in Me	chatronics (L1524)	Project-/problem-based Le	arning 3	4
Module Responsible	Prof. Thorsten Kern			
Admission Requirements	None			
Recommended Previous	Basics of mechanical design, electrical de	sign or computer-sciences		
Knowledge				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	Science-based working on interdisciplinar	y product design considering targeted application	n of specific product	design technique
Skills	s Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application			
	various product design techniques followi	ng theoretical aspects.		
Personal Competence				
Social Competence	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application			
	common, creative methodologies.			
Autonomy	Students are enabled to optimize the des	ign and development process according to the ta	arget and topic of the	e design
Workload in Hours	Independent Study Time 110, Study Time	e in Lecture 70		
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and	30 min Presentation for a group design-w	ork		
scale				
Assignment for the	International Management and Engineerin	ng: Specialisation II. Product Development and P	roduction: Elective C	ompulsory
Following Curricula	International Management and Engineerin	ng: Specialisation II. Mechatronics: Elective Com	oulsory	
	Mechanical Engineering and Management	t: Specialisation Product Development and Produ	ction: Elective Comp	oulsory
	Mechatronics: Specialisation System Desi	gn: Elective Compulsory		
	Biomedical Engineering: Specialisation Ar	tificial Organs and Regenerative Medicine: Electi	ve Compulsory	
	Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Elective Compulsor	/	
	Biomedical Engineering: Specialisation Me	edical Technology and Control Theory: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Ma	anagement and Business Administration: Elective	e Compulsory	
	Theoretical Mechanical Engineering: Spec	ialisation Product Development and Production:	Elective Compulsory	,
	Theoretical Mechanical Engineering: Tech	inical Complementary Course: Elective Compulso	orv	

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

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 M0805: Tech	ical Acoustics I (Acoustic Waves, No	ise Protection, Psycho Aco	ustics)	
Courses				
Title		Тур	Hrs/wk	СР
Technical Acoustics I (Acoustic Wa	es, Noise Protection, Psycho Acoustics) (L0516)	Lecture	2	3
Technical Acoustics I (Acoustic Way	es, Noise Protection, Psycho Acoustics) (L0518)	Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and Mech	hanics II (Hydrostatics, Kinematics, Dyn	amics)	
Knowledge	Mathematics I, 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 an in-depth knowledge in acou	stics regarding acoustic waves, noise	protection, and p	sycho acoustics a
	are able to give an overview of the corresponding the	oretical and methodical basis.		
Skills	The students are capable to handle engineering		ased application	of the demandi
	methodologies and measurement procedures treated within the module.			
Personal Competence				
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.			
Autonomy	my The students are able to independently solve challenging acoustical problems in the areas treated within the modu			the module. Possib
	conflicting issues and limitations can be identified and	I the results are critically scrutinized.		
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				
Assignment for the	Energy Systems: Core qualification: Elective Compulso	ory		
Following Curricula	Aircraft Systems Engineering: Core qualification: Elect	ive Compulsory		
	International Management and Engineering: Specialisa	ation II. Aviation Systems: Elective Com	pulsory	
	Mechatronics: Specialisation System Design: Elective	Compulsory		
	Product Development, Materials and Production: Core	qualification: Elective Compulsory		
	Technomathematics: Specialisation III. Engineering Sc	ience: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Comple	ementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Pro	oduct Development and Production: Elec	ctive Compulsory	

Course L0516: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Otto von Estorff	
Language	EN	
Cycle	SoSe	
Content	- Introduction and Motivation	
	- Acoustic quantities	
	- Acoustic waves	
	- Sound sources, sound radiation	
	- Sound engergy and intensity	
	- Sound propagation	
	- Signal processing	
	- Psycho acoustics	
	- Noise	
	- Measurements in acoustics	
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 Aco	ourse L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	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		

Courses				
Title		Тур	Hrs/wk	СР
Experimental Methods for the Characterization of Materials (L1580)		Lecture	2	3
Phase equilibria and transformation		Lecture	2	3
Module Responsible				
Admission Requirements	None			
	Basic knowledge in Materials Science, e.g. W	erkstoffwissenschaft I/II		
Knowledge				
Educational Objections				
-	After taking part successfully, students have	reactied the following learning results		
Professional Competence	The shudests will be able to a shift of		- Alexandra - Marcola - Contra - C	
Knowledge	The students will be able to explain the prop	-		inology, in particul
	metallic, ceramic, polymeric, semiconductor,	modern composite materiais (blomater	iais) and nanomaterials.	
Skills	The students will be able to select materia	al configurations according to the tech	nical needs and, if neces	sary, to design ne
	materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview or			
	modern materials science, which enables	them to select optimum materials	s combinations dependir	ng on the techni
	applications.			
Personal Competence				
Social Competence	The students are able to present solutions to	specialists and to develop ideas further		
Autonomy	The students are able to			
	 assess their own strengths and weakn 	esses.		
	• gather new necessary expertise by the	eir own.		
	Independent Study Time 124, Study Time in	Lecture 56		
Credit points Course achievement				
Examination	Written exam			
Examination duration and	90 min			
scale	30 mm			
	International Management and Engineering:	Specialisation II Product Development	and Production: Elective Co	ompulsory
Following Curricula	Materials Science: Core qualification: Compu			anipaisory
i onowing curricula	Product Development, Materials and Product	•	: Elective Compulsory	
	Product Development, Materials and Product			
	Product Development, Materials and Product			
	Theoretical Mechanical Engineering: Technica		-	
	Theoretical Mechanical Engineering: Specialis			

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	 Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
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 equilib	ria and transformations
· · ·	Lecture
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Jörg Weißmüller
Language	
Cycle	
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.

6				
Courses				
Title	,	Тур	Hrs/wk	СР
Boundary Element Methods (L0523		Lecture Recitation Section (large)	2 2	3 3
Boundary Element Methods (L0524		Recitation Section (large)	Z	3
Module Responsible				
Admission Requirements	None			
	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics)			
Knowledge	Mathematics I, II, III (in particula	Ifferential equations)		
Educational Objectives	After taking part successfully, s	ents have reached the following learning results		
Professional Competence				
Knowledge	The students possess an in-de	knowledge regarding the derivation of the boundary el	ement method an	d are able to give
	overview of the theoretical and			, , , , , , , , , , , , , , , , , , ,
	overview of the theoretical and			
Skills	The students are capable to	andle engineering problems by formulating suitable	boundary eleme	ents, assembling i
	corresponding system matrices	nd solving the resulting system of equations.		
Personal Competence				
-	Students can work in small grou	on specific problems to arrive at joint solutions.		
	Stadents can north shan groe			
Autonomy	The students are able to indep	dently solve challenging computational problems and de	evelop own bound	ary element routin
	Problems can be identified and	results are critically scrutinized.		
Workload in Hours	Independent Study Time 124, S	ly Time in Lecture 56		
Credit points	6			
Course achievement	Compulsory Bonus Form	Description		
	No 20 % Midterm			
Examination	Written exam			
Examination duration and	90 min			
scale				
	Civil Engineering: Specialisation	ructural Engineering: Elective Compulsory		
Following Curricula		eotechnical Engineering: Elective Compulsory		
Following Curricula				
		bastal Engineering: Elective Compulsory		
	Energy Systems: Core qualificat			
		gement: Specialisation Product Development and Produc	tion: Elective Com	pulsory
	Mechatronics: Specialisation Sy			
	Product Development, Materials	nd Production: Core qualification: Elective Compulsory		
	Technomathematics: Specialisa	n III. Engineering Science: Elective Compulsory		
	Theoretical Mechanical Enginee	g: Technical Complementary Course: Elective Compulsor	у	

Course L0523: Boundary Eler	ment Methods
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
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
	//ppicodono
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 Elei	se L0524: Boundary Element Methods		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	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		

	Order FEM					
Courses						
			-			
Title High-Order FEM (L0280)			Typ Lecture		Hrs/wk 3	CP 4
High-Order FEM (L0281)			Recitation Se	ction (large)	1	2
Module Responsible	Prof. Alexander Dü	ster				
Admission Requirements						
Recommended Previous	Knowledge of partial differential equations is recommended.					
Knowledge						
Educational Objectives	After taking part su	iccessfully, students hav	ve reached the following learning re	sults		
Professional Competence						
	Students are able t	0				
5			p) finite element procedures.			
	+ explain high-orde	er finite element proced	ures.			
	+ specify problem	s of finite element pro	cedures, to identify them in a giv	en situation and	to explain the	ir mathematical a
	mechanical backgro	ound.				
Skille	Students are able t	0				
JKIIIS			ems of structural mechanics.			
			nechanics a suitable finite element	procedure		
	-	esults of high-order finit		procedure.		
		•	nite elements to new problems.			
Personal Competence						
Social Competence	Students are able to + solve problems in heterogeneous groups and to document the corresponding results.					
	+ solve problems in	n neterogeneous groups	and to document the corresponding	ig results.		
Autonomy	Students are able t	0				
	+ assess their know	wledge by means of exe	rcises and E-Learning.			
	+ acquaint themse	lves with the necessary	knowledge to solve research orient	ted tasks.		
Workload in Hours	Independent Study	Time 124, Study Time	n Lecture 56			
Credit points	6	-				
Course achievement	Compulsory Bonus	Form	Description			
	No 10 %	Presentation	Forschendes Lernen			
Examination	Written exam					
Examination duration and	120 min					
scale	ļ					
Assignment for the	Energy Systems: Co	ore qualification: Electiv	re Compulsory			
Following Curricula			g: Specialisation II. Product Develop	ment and Produc	tion: Elective Co	ompulsory
		Specialisation Modeling				
	5	5 5	Specialisation Product Developmen	nt and Production	: Elective Comp	ulsory
			ourse: Elective Compulsory			
			ction: Core qualification: Elective C			
			: Core qualification: Elective Compu ineering Science: Elective Compuls			
				ULV.		
			ical Complementary Course: Electiv	-		

Тур	Lecture			
Hrs/wk	3			
CP	4			
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42			
Lecturer	Prof. Alexander Düster			
Language	EN			
Cycle	SoSe			
Content	1. Introduction			
	2. Motivation			
	3. Hierarchic shape functions			
	4. Mapping functions			
	5. Computation of element matrices, assembly, constraint enforcement and solution			
	6. Convergence characteristics			
	7. Mechanical models and finite elements for thin-walled structures			
	8. Computation of thin-walled structures			
	9. Error estimation and hp-adaptivity			
	10. High-order fictitious domain methods			
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 Fl	ourse L0281: High-Order FEM		
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	2		
Workload in Hours	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		

plain humanoid robots.	Typ Seminar		CP 2
nd design ssfully, students have reach plain humanoid robots.	Seminar	2	
nd design ssfully, students have reach plain humanoid robots.			
nd design ssfully, students have reach plain humanoid robots.			
nd design ssfully, students have reach plain humanoid robots.			
plain humanoid robots.			
	epts for different tasks in humand	oid robotics.	
 Students acquire knowledge about selected aspects of humanoid robotics, based on specified literature Students generalize developed results and present them to the participants Students practice to prepare and give a presentation 			
rize themselves with a sci			
e 32, Study Time in Lecture	re 28		
ation Intelligent Systems a	and Robotics: Elective Compulsor	ry	
y: Specialisation Artificial Or g: Specialisation Implants an g: Specialisation Medical Te g: Specialisation Manageme	Organs and Regenerative Medicin and Endoprostheses: Elective Cor echnology and Control Theory: El ent and Business Administration:	mpulsory lective Compulsory : Elective Compulsory	
	alize developed results and ce to prepare and give a pro- pable of developing solutio op provide appropriate feedba ate advantages and drawl arize themselves with a sc ntific discussion develops ne 32, Study Time in Lectur sation Intelligent Systems a sation System Design: Elec g: Specialisation Artificial C g: Specialisation Implants a g: Specialisation Medical To g: Specialisation Medical To g: Specialisation Managem I Engineering: Technical Co	alize developed results and present them to the participant ce to prepare and give a presentation pable of developing solutions in interdisciplinary teams and o provide appropriate feedback and handle constructive crit ate advantages and drawbacks of different forms of pre arize themselves with a scientific field, are able of introduntific discussion develops ne 32, Study Time in Lecture 28 sation Intelligent Systems and Robotics: Elective Compulso sation System Design: Elective Compulsory g: Specialisation Artificial Organs and Regenerative Medicir g: Specialisation Medical Technology and Control Theory: E g: Specialisation Management and Business Administration I Engineering: Technical Complementary Course: Elective Co	alize developed results and present them to the participants ce to prepare and give a presentation pable of developing solutions in interdisciplinary teams and present them o provide appropriate feedback and handle constructive criticism of their own results ate advantages and drawbacks of different forms of presentation for specific tasks arize themselves with a scientific field, are able of introduce it and follow presentation ntific discussion develops ne 32, Study Time in Lecture 28 sation Intelligent Systems and Robotics: Elective Compulsory

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

Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Ident	fication (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Classical control (frequency respo	inse, root locus)		
	State space methods			
	Discrete-time systems	amposition		
	 Linear algebra, singular value dec Basic knowledge about stochastic 			
		processes		
Educational Objectives	After taking part successfully, students h	nave reached the following learning results		
Professional Competence				
Knowledge				
		I framework of the prediction error method	and its application to a	variety of linear a
	nonlinear model structures	arcontron notworks are used to model nonlik	oor dynamics	
		perceptron networks are used to model nonlir nate predictive control scheme can be based		le
		pace identification and its relation to Kalman		15
	• They can explain the idea of subs			
Skills	. Chudanta and sample of analysis		in antal identification of	linear and sealing
	 Students are capable of applying models for dynamic systems 	g the predicition error method to the exper	imental identification of	linear and nonline
		g a nonlinear predictive control scheme based	t on a noural notwork mo	dol
		space algorithms to the experimental identific		
		dard software tools (including the Matlab Sys		
		and software tools (including the Matlab Sys		
Personal Competence				
Social Competence	Students can work in mixed groups on s	pecific problems to arrive at joint solutions.		
Autonomu	Students are able to find required inform	nation in sources provided (lecture notes, lite	ratura, coftwara documa	ntation) and use it
Autonomy	solve given problems.	nation in sources provided (lecture notes, lite	fature, software docume	ntation) and use it
	solve given problems.			
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Co	ntrol and Power Systems Engineering: Electiv	e Compulsory	
-		Systems and Robotics: Elective Compulsory		
U U	Mechatronics: Specialisation System Des			
		Artificial Organs and Regenerative Medicine: E	ective Compulsory	
	• • •	mplants and Endoprostheses: Elective Compu		
		۰ Iedical Technology and Control Theory: Comp		
	• • •	Aanagement and Business Administration: Ele		
		hnical Complementary Course: Elective Com		
	Theoretical Mechanical Engineering: Cor		-	

Course L0660: Linear and No	onlinear System Identification		
Тур	Lecture		
Hrs/wk			
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Herbert Werner		
Language	EN		
Cycle	SoSe		
Content	 Prediction error method Linear and nonlinear model structures Nonlinear model structure based on multilayer perceptron network Approximate predictive control based on multilayer perceptron network model Subspace identification 		
Literature	 Lennart Ljung, System Identification - Theory for the User, Prentice Hall 1999 M. Norgaard, O. Ravn, N.K. Poulsen and L.K. Hansen, Neural Networks for Modeling and Control of Dynamic Systems Springer Verlag, London 2003 T. Kailath, A.H. Sayed and B. Hassibi, Linear Estimation, Prentice Hall 2000 		

Module M0752: Nonli	near Dynamics			
Courses				
Title Nonlinear Dynamics (L0702)		Typ Integrated Lecture	Hrs/wk 4	CP 6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusLinear AlgebraEngineering Mechanics			
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
-	Students are able to reflect existing terms and conce concepts. Students are able to apply existing methods and proces			
Personal Competence	Students are able to apply existing methods and proces	ares of Norminear Dynamics and to	develop novel met	
	Students can reach working results also in groups.			
Autonomy		vidually and to identify and follow	up novel research ta	sks by themselves
	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
	Written exam			
Examination duration and scale				
Assignment for the	Aircraft Systems Engineering: Core qualification: Electiv	e Compulsory		
Following Curricula	International Management and Engineering: Specialisat	on II. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management: Specialisatio	n Mechatronics: Elective Compulso	ry	
	Mechatronics: Specialisation System Design: Elective Co	mpulsory		
	Mechatronics: Specialisation Intelligent Systems and Ro			
	Biomedical Engineering: Specialisation Artificial Organs	•		
	Biomedical Engineering: Specialisation Implants and Engineering			
	Biomedical Engineering: Specialisation Medical Technolo			
	Biomedical Engineering: Specialisation Management an Product Development, Materials and Production: Core q		compulsory	
	Theoretical Mechanical Engineering: Technical Complen		rv	
	Theoretical Mechanical Engineering: Core qualification:		.,	

Course L0702: Nonlinear Dynamics		
Тур	Integrated Lecture	
Hrs/wk	4	
СР	6	
Workload in Hours	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				
Title		Тур	Hrs/wk	СР
Lagrangian transport in turbulent fl		Lecture	2	3
Computational Fluid Dynamics - Ex Computational Fluid Dynamics in P		Recitation Section (small) Lecture	1 2	1 2
		Lecture	Z	Z
Module Responsible				
Admission Requirements	None			
Recommended Previous	Mathematics I-IV			
Knowledge	Basic knowledge in Fluid Mechanics			
	Basic knowledge in chemical thermodynamics			
		the Caller State Landstein and Ba		
	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	After successful completion of the module the studen	ts are able to		
	explain the the basic principles of statistical th	ermodynamics (ensembles, simple sys	tems)	
	 describe the main approaches in classical Mole 	cular Modeling (Monte Carlo, Molecula	r Dynamics) in var	ious ensembles
	 discuss examples of computer programs in det 	ail,		
	 evaluate the application of numerical simulations, 			
	 list the possible start and boundary conditions 	for a numerical simulation.		
Skills The students are able to:				
	• set up computer programs for solving simple p	roblems by Mente Carle or melecular	hunamica	
	 set up computer programs for solving simple p solve problems by molecular modeling, 	roblems by Monte Carlo of Molecular (lynamics,	
	 set up a numerical grid, perform a simple numerical simulation with Op 	onFoom		
	 evaluate the result of a numerical simulation. 	enroam,		
	• evaluate the result of a numerical sinulation.			
Personal Competence				
	The students are able to			
	 develop joint solutions in mixed teams and present them in front of the other students, 			
	 to collaborate in a team and to reflect their own contribution toward it. 			
Autonomy	The students are able to:			
			h	
	evaluate their learning progress and to define		Dasis,	
	 evaluate possible consequences for their profe 	ssion.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture	70		
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and	30 min			
scale				
5	Bioprocess Engineering: Specialisation A - General Bio		,	
Following Curricula				
	Chemical and Bioprocess Engineering: Specialisation	• •		
	Chemical and Bioprocess Engineering: Specialisation			loon (
	Energy and Environmental Engineering: Specialisation			lisory
	Theoretical Mechanical Engineering: Technical Compl		/	
	Theoretical Mechanical Engineering: Specialisation Er			
	Theoretical Mechanical Engineering: Specialisation Si		SULA	
	Process Engineering: Specialisation Chemical Process			
	Process Engineering: Specialisation Process Engineer	na: Elective Compulson		

Course L2301: Lagrangian transport in turbulent flows	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. 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 methods (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
	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. $ ightarrow$ 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. \rightarrow Knowledge, social competence
	Required knowledge:
	Fluid mechanics 1 and 2 advantageous
	Programming knowledge advantageous
Literature	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.
	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. DOI: 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	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Michael Schlüter	
Language	EN	
Cycle	SoSe	
Content	 generation of numerical grids with a common grid generator selection of models and boundary conditions basic numerical simulation with OpenFoam within the TUHH CIP-Pool 	
Literature	OpenFoam Tutorials (StudIP)	

Course L1052: Computationa	I 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	 Introduction into partial differential equations Basic equations Boundary conditions and grids Numerical methods Finite difference method Finite volume method Time discretisation and stability Population balance Multiphase Systems Modeling of Turbulent Flows Exercises: Stability Analysis Exercises: Example on CFD - analytically/numerically
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 M0605: Comp	utational Structural Dynamics				
Courses					
Title		Тур	Hrs/wk	СР	
Computational Structural Dynamics (L0282)		Lecture	3	4	
Computational Structural Dynamics (L0283)		Recitation Section (small)	1	2	
Module Responsible	Prof. Alexander Düster				
Admission Requirements	None				
Recommended Previous	Knowledge of partial differential equations is	recommended.			
Knowledge					
Educational Objectives	After taking part successfully, students have	reached the following learning results			
Professional Competence					
Knowledge	Students are able to				
	+ give an overview of the computational proc	cedures for problems of structural dynamics.			
	+ explain the application of finite element pro	ograms to solve problems of structural dynamic	5.		
	+ specify problems of computational structure	ral dynamics, to identify them in a given situat	ion and to explai	n their mathemati	
	and mechanical background.				
Skille	Students are able to				
JKIIIS	+ 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 an	nd to document the corresponding results.			
Autonomy	Students are able to				
hatohomy	+ acquire independently knowledge to solve complex problems.				
Workload in Hours	Independent Study Time 124, Study Time in L	Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	2h				
scale					
Assignment for the	International Management and Engineering: S	Specialisation II. Mechatronics: Elective Compuls	ory		
Following Curricula	Materials Science: Specialisation Modeling: El	ective Compulsory			
	Mechatronics: Technical Complementary Cou	rse: Elective Compulsory			
	Naval Architecture and Ocean Engineering: C	ore qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Technica	al Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialis	ation Simulation Technology, Elective Compuls	201		

Course L0282: Computational 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	1. Motivation	
	2. Basics of dynamics	
	3. Time integration methods	
	4. Modal analysis	
	5. Fourier transform	
	6. Applications	
Literature	[1] KJ. Bathe, Finite-Elemente-Methoden, Springer, 2002.	
	[2] J.L. Humar, Dynamics of Structures, Taylor & Francis, 2012.	

Course L0283: Computationa	urse L0283: Computational Structural Dynamics		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
Workload in Hours	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		Тур	Hrs/wk	СР
Optimal and Robust Control (L0658 Optimal and Robust Control (L0659		Lecture Recitation Section (small)	2	3
		Recitation Section (smail)	Z	3
Module Responsible				
	None			
Recommended Previous Knowledge	Classical control (frequency response, root locus)			
Knowledge	State space methods			
	Linear algebra, singular value decomposition			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence	Arter taking part successiony, students have reached the	Tonowing learning results		
Knowledge				
Kilowieuge	Students can explain the significance of the matrix	Riccati equation for the solution of	LQ problems.	
	They can explain the duality between optimal state feedback and optimal state estimation.			
	• They can explain how the H2 and H-infinity norms	are used to represent stability and p	erformance cons	traints.
	• They can explain how an LQG design problem can			
	They can explain how model uncertainty can be re			
	 They can explain how - based on the small gain the sm	neorem - a robust controller can gu	arantee stability	and performance
	an uncertain plant.They understand how analysis and synthesis conditions on feedback loops can be represented as linea			
	They understand now analysis and synthesis condi-	lons on reedback loops can be repre	esented as intear	matrix mequaliti
Skills	ills			
 Students are capable of designing and tuning LQG controllers for multivariable plant models. They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, a 				nd of using stan
	software tools for solving it.	design problem in the form of a get	neralizeu plant, a	ind of dailing starts
	 They are capable of translating time and frequency domain specifications for control loops into constri- 			
	sensitivity functions, and of carrying out a mixed-s			
	• They are capable of constructing an LFT uncertai		, and of designir	ng a mixed-objed
	robust controller.			5
	They are capable of formulating analysis and synt	nesis conditions as linear matrix ine	qualities (LMI), a	nd of using stand
	LMI-solvers for solving them.			
	They can carry out all of the above using standard	software tools (Matlab robust contro	ol toolbox).	
Personal Competence				
	Students can work in small groups on specific problems to	arrive at joint solutions		
,	Students are able to find required information in sources		oftware docume	ntation) and use
Autonomy	solve given problems.	provided (lecture notes, incluture, s		
	solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and				
scale	50 1111			
•	Electrical Engineering: Specialisation Control and Power S	ystems Engineering: Elective Compo	ulsory	
Following Curricula	Energy Systems: Core qualification: Elective Compulsory			
	Aircraft Systems Engineering: Core qualification: Elective			
	Mechatronics: Specialisation Intelligent Systems and Robe			
	Mechatronics: Specialisation System Design: Elective Con Biomedical Engineering: Specialisation Artificial Organs a		Compulson	
	Biomedical Engineering: Specialisation Artificial Organs an Biomedical Engineering: Specialisation Implants and Endo		Lompuisory	
	Biomedical Engineering: Specialisation Implants and Endo Biomedical Engineering: Specialisation Medical Technolog		oulsory	
	Biomedical Engineering: Specialisation Management and			
	Product Development, Materials and Production: Specialisation			
	Product Development, Materials and Production: Specialis			
	Product Development, Materials and Production: Specialis		-	
	Theoretical Mechanical Engineering: Technical Compleme			
	Theoretical Mechanical Engineering: Core qualification: El			

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

Course L0659: Optimal and F	Course L0659: Optimal and Robust 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	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses					
		T	Line (colo	CD	
Title	0237)	Typ Lecture	Hrs/wk 2	СР 3	
Computational Fluid Dynamics II (L0237) Computational Fluid Dynamics II (L0421)		Recitation Section (large)	2	3	
Module Responsible					
Admission Requirements					
Recommended Previous	Basics of computational and general the	rmo/fluid dynamics			
Knowledge					
Educational Objectives	After taking part successfully, students h	ave reached the following learning results			
Professional Competence					
Knowledge	Establish a thorough understanding of Finite-Volume approaches. Familiarise with details of the theoretical background of comple				
	CFD algorithms.				
<i>CL 11</i>					
SKIIIS	s 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 team ex	ercises			
,	Indenpendent analysis of specific solutio				
	Independent Study Time 124, Study Tim				
Credit points					
Course achievement					
Examination					
Examination duration and					
scale	0.511 0.7511				
	Energy Systems: Core qualification: Elect	tive Compulsory			
-		ng: Core qualification: Elective Compulsory			
-	Theoretical Mechanical Engineering: Tec	hnical Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Cor	e qualification: Elective Compulsory			

Course L0237: Computationa	al 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
	J.H. Ferziger, M. Peric:
	Computational Methods for Fluid Dynamics,
	Springer

Course L0421: Computationa	al 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					
Title		Typ Lecture	Hrs/wk 3	CP 4	
Systems Engineering (L1547) Systems Engineering (L1548)		Recitation Section (large)	1	2	
Module Responsible	Prof Palf God		-	-	
Admission Requirements					
Recommended Previous	Mathematics				
Kilowieuge	Machanics				
	Thermodynamics				
	Electrical Engineering				
	Control Systems				
	control systems				
	Previous knowledge in:				
	Aircraft Cabin Systems				
Educational Objectives	After taking part successfully, students have reach	ed the following learning results			
Professional Competence	Their taking part successivity, stadents have react				
•	Students are able to:				
Knowledge	 understand systems engineering process models 	methods and tools for the development o	f complex System	26	
	 describe innovation processes and the need for the 		i complex system	15	
	 explain the aircraft development process and the explain the system development process, including 				
	 identify environmental conditions and test proce 	• • • • •			
	 value the methodology of requirements-based end 		ments engineerin	a (MBRE)	
				<u>, , , , , , , , , , , , , , , , , , , </u>	
Skills	Skills Students are able to:				
	plan the process for the development of complex Systems				
	 organize the development phases and developm 				
	assign required business activities and technical Tasks				
	 apply systems engineering methods and tools 				
Personal Competence					
-	Students are able to:				
	 understand their responsibilities within a develop 	oment team and integrate themselves with	their role in the o	overall process	
		5			
Autonomy	Students are able to:				
	 interact and communicate in a development tear 	m which has distributed tasks			
Workload in Hours	Independent Study Time 124, Study Time in Lectu	re 56			
Credit points					
Course achievement					
	Written exam				
Examination duration and scale	120 Minutes				
	Alizzanth Suchama Englis aniga aniga Care anglitication. C				
-	Aircraft Systems Engineering: Core qualification: C				
Following Curricula	International Management and Engineering: Speci-				
	International Management and Engineering: Speci-	•	action: Elective Co	unpuisory	
	Mechatronics: Specialisation System Design: Elect				
	Mechatronics: Specialisation Intelligent Systems and Broduct Development. Materials and Broductions S		loon		
	Product Development, Materials and Production: S		-		
	Product Development, Materials and Production: S				
	Product Development, Materials and Production: S		у		
	Theoretical Mechanical Engineering: Technical Cor		nnulcon.		
	Theoretical Mechanical Engineering: Specialisation	And an Systems Engineering: Elective Cor	iipuisol y		

Lecturer Language Cycle	4 Independent Study Time 78, Study Time in Lecture 42 Prof. Ralf God DE SoSe 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.
Workload in Hours Lecturer Language Cycle	Independent Study Time 78, Study Time in Lecture 42 Prof. Ralf God DE SoSe The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integratio of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineerin process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known.
Lecturer Language Cycle	Prof. Ralf God DE SoSe The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integratio of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineerin process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known.
Language Cycle	DE SoSe 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.
Cycle	SoSe The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integratic of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineerin process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known.
-	The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integratic of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineerin process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known.
Content	of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineerin process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known.
	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 ar
	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	- Skript zur Vorlesung
	- diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE)
	- Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010
	- NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007
	- Hinsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation luftfahrttechnischer Betriebe. Springer, 2010
	 De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010 Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt.Verlag, 2008

Course L1548: Systems Engi	ourse L1548: Systems Engineering	
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	2	
Workload in Hours	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	

Courses				
Title		Тур	Hrs/wk	СР
Experimental Micro- and Nanomechanics (L1673)		Lecture	2	4
Experimental Micro- and Nanomechanics (L1674) Recitation Section (small)			1	2
Module Responsible	Dr. Erica Lilleodden			
Admission Requirements	None			
Recommended Previous	Basics in Materials Science I/II, Mechanical Properties, Phenomena and Methods in Materials Science			
Knowledge				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	Students are able to describe the princi	ples of mechanical behavior (e.g., stress, strain, i	modulus, strengtl	n, hardening, failu
	fracture).			
	Students can explain the principles of characterization methods used for investigating microstructure (e.g., scanning electro			
	microscopy, x-ray diffraction)			
	They can describe the fundamental relations between microstructure and mechanical properties.			
Skills	s Students are capable of using standardized calculation methods to calculate and evaluate mechanical properties			properties (modu
	strength) of different materials under varying loading states (e.g., uniaxial stress or plane strain).			
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 weaknes 	ses		
	- assess their own state of learning in specific terms and to define further work steps on this basis guided by teachers.			
		ed on lectures and notes to solve problems, and	to ask for help o	r clarifications wh
	needed			
Workload in Hours	Independent Study Time 138, Study Time	in Lecture 42		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Nano and	d Hybrid Materials: Elective Compulsory		
Following Curricula	Theoretical Mechanical Engineering: Spec	ialisation Materials Science: Elective Compulsory		
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective Compulsory		

-	Micro- and Nanomechanics
	Lecture
Hrs/wk	2
CP	4
Workload in Hours	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 metal
	materials, though issues related to ceramics and polymeric materials will also be discussed. Modern methods will be explore
	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
Workload in Hours	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: Mech	anical Properties			
Courses				
Title Mechanical Behaviour of Brittle Ma		Typ Lecture	Hrs/wk	CP 3
Dislocation Theory of Plasticity (L1		Lecture	2	3
Module Responsible				
Admission Requirements Recommended Previous Knowledge	Basics in Materials Science I/II			
Educational Objectives	After taking part successfully, students ha	ave reached the 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 standardize	ed calculation methods: tensor calculations, de	rivatives, integrals, ter	nsor transformatior
Personal Competence				
Social Competence	Students can provide appropriate feedbac	ck and handle feedback on their own performa	nce constructively.	
Autonomy	y Students are able to			
	- assess their own strengths and weaknes	sses		
	- assess their own state of learning in spe	cific terms and to define further work steps on	this basis guided by te	eachers.
	- work independently based on lectures a	nd notes to solve problems, and to ask for help	o or clarifications when	needed
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Materials Science: Core qualification: Con	npulsory		
Following Curricula		t: Specialisation Materials: Elective Compulsory		
		luction: Specialisation Product Development: E		
		luction: Specialisation Production: Elective Com	npulsory	
		luction: Specialisation Materials: Compulsory		
		ialisation Materials Science: Elective Compulso	•	
	Theoretical Mechanical Engineering: Tech	inical Complementary Course: Elective Compul	sory	

Course L1661: Mechanical Be	ehaviour of Brittle Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Gerold Schneider
Language	DE/EN
Cycle	SoSe
Content	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,
	Heterogeneous materials II
	Toughening mechanisms: crack bridging, fibres
	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
Literature	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: Dislocation Th	neory of Plasticity
	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Erica Lilleodden
Language	DE/EN
Cycle	SoSe
Content	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. 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

F itle Quantum Mechanics of Solids (L167! Quantum Mechanics of Solids (L167!	5)					
	5)		Тур	Hrs/wk	СР	
uantum Mechanics of Solids (L167)			Lecture	2 1	4 2	
	6)		Recitation Section (small)			
Module Responsible	Prof. Stefan Müller					
Admission Requirements	None					
Recommended Previous Knowledge	Knowledge of advanced mathemation I-IV	cs like analysis, linear alg	gebra, differential equations and	complex functior	ns, e.g., Mathemati	
	Knowledge of mechanics and physic	s, particularly solid state	physics, e.g., Materials Physics			
Educational Objectives	After taking part successfully, stude	nts have reached the fol	lowing learning results			
Professional Competence						
Knowledge	The master students will be able to	explain				
	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 materials.					
	The master students will then be able to connect essential materials properties in engineering with materials atomistic scale in order to understand these connections.				als properties on t	
Skills	s After attending this lecture the students can					
	perform materials design on a qua	antum mechanical basis.				
Personal Competence						
	The students are able to discuss competently quantum-mechanics-based subjects with experts from fields such as physics an materials science.					
-	The students are able to independently develop solutions to quantum mechanical problems. They can also acquire the knowledge they need to deal with more complex questions with a quantum mechanical background from the literature.					
Workload in Hours	Independent Study Time 138, Study	Time in Lecture 42				
Credit points	6					
Course achievement	None					
Examination	Oral exam					
Examination duration and						
scale						
•	Materials Science: Specialisation Na					
-	Materials Science: Specialisation Mo		•			
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory					

Course L1675: Quantum Mec	hanics of Solids
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	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
Literature	Physik für Ingenieure, Hering/Martin/Stohrer, Springer
	Atom- und Quantenphysik, Haken/Wolf, Springer
	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: Quantum Med	ourse L1676: Quantum Mechanics of Solids		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
Workload in Hours	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		

Courses						
Title		Тур	Hrs/wk	СР		
Methods in Theoretical Materials S	cience (L1677)	Lecture	2	4		
Methods in Theoretical Materials S	cience (L1678)	Recitation Section (small)	1	2		
Module Responsible	Prof. Stefan Müller					
Admission Requirements	None					
Recommended Previous	Knowledge of advanced mathematics like analysis, linear algebra, differential equations and complex functions, e.g., Mathematic					
Knowledge						
	Knowledge of physics, particularly solid state pl	nysics, e.g., Materials Physics				
		and a state of the state of the state of the				
	After taking part successfully, students have re-	ached the following learning results				
Professional Competence	The master students will be able to					
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 w expected from the simulation results.					
Skills	s After completing the module, the students are able to					
	select the most suitable modeling method as a function of various parameters such as length scale, tir material type, etc					
Personal Competence						
Social Competence	The students are able to discuss competently and materials science, for example at conferer groups.					
Autonomy	The students are able to					
	assess their own strengths and weaknesses.					
	acquire the knowledge they need on their own.					
Workload in Hours	Independent Study Time 138, Study Time in Le	cture 42				
Credit points						
Course achievement						
Examination	Oral exam					
Examination duration and scale						
Assignment for the	Materials Science: Specialisation Modeling: Elec	tive Compulsory				
Following Curricula	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory					
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory					

Course L1677: Methods in Th	neoretical Materials Science
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Stefan Müller
Language	DE/EN
Cycle	SoSe
Content	1. Introduction
	1.1 Classification of Modelling Approaches and the Solid State
	2. Quantum Mechanical Approaches
	2.1 Electronic states : Atoms, Molecules, Solids
	2.2 Density Functional Theory
	2.3 Spin-Dynamics
	3. Thermodynamic Approaches
	3.1 Thermodynamic Potentials
	3.2 Alloys
	3.3 Cluster Expansion
	3.4 Monte-Carlo-Methods
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 Th	ourse L1678: Methods in Theoretical Materials Science		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
Workload in Hours	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 M0641: Stear	n Generators					
Courses						
Title			Тур	Hrs/wk	СР	
Steam Generators (L0213)			Lecture	3	5	
Steam Generators (L0214)			Recitation Section (large)	1	1	
Module Responsible	Dr. Kristin Abel-Günth	her				
Admission Requirements	None					
Recommended Previous	"Technical Thermodynamics I and II"					
Knowledge	 "Heat Transfer 	-				
	 "Fluid Mechani 					
	"Steam Power	Plants"				
Educational Objectives	After taking part succ	cessfully, students hav	re reached the following learning results			
Professional Competence						
Knowledge						
	The students know the	ne thermodynamic ba	se principles for steam generators and their ty	pes. They are able	to describe the bas	
	principles of steam g	enerators and sketch	the combustion and fuel supply aspects of fossi	l-fuelled power plar	nts. They can perfor	
	-		the water-steam side, as well as they are able			
	-		e and evaluate the operational behaviour of ste	eam generators and	d explain these in th	
	context of related dis	ciplines.				
Skills						
	The students will be a	able, using detailed kn	nowledge on the calculation, design, and constru	uction of steam ger	erators, linked with	
	wide theoretical and	methodical foundation	n, to understand the main design and construction	on aspects of stean	n generators. Throu	
	problem definition ar	nd formalisation, mode	elling of processes, and training in the solution r	nethodology for pa	rtial problems a go	
	overview of this key of	component of the pow	er plant will be obtained.			
	Within the framework	< of the exercise the s	tudents obtain the ability to draw the balances,	and design the ste	am generator and i	
	components. For this	purpose small but clo	se to lifelike tasks are solved, to highlight aspec	ts of the design of	steam generators.	
Personal Competence						
		exercises the focus is	s placed on communication with the tutor. This a	animates the stude	nts to reflect on the	
	existing knowledge a	nd ask specific question	ons to further improve their understanding.			
Autonomy	,					
		able to perform basi	c calculations covering aspects of the steam of	enerator, with onl	y the help of small	
			cal and practical knowledge from the lecture i			
	from different proces	s schemata and bound	dary conditions are highlighted.			
Workload in Hours	Independent Study T	ime 124, Study Time i	n Lecture 56			
Credit points	6					
Course achievement		Form	Description			
	No 5%	Excercises	Den Studierenden wird eine kleine Auf	5		
			der Vorwoche gestellt. Die Antworte			
			gegeben werden, aber auch Zeichnung Multiple Choice sind möglich.	en, Sticnpunkte od	er, in seitenen Falle	
Examination	Written exam		Multiple choice sind moglien.			
Examination duration and	120 min					
scale	120 mm					
Assignment for the	Energy Systems: Spe	cialisation Energy Sys	tems: Elective Compulsory			
Following Curricula	Energy Systems: Spe	cialisation Marine Eng	ineering: Elective Compulsory			
	Energy Systems: Spe	cialisation Energy Syst	tems: Elective Compulsory			
	International Manage	ment and Engineering	g: Specialisation II. Energy and Environmental Er	igineering: Elective	Compulsory	
	Theoretical Mechanic	al Engineering: Techni	ical Complementary Course: Elective Compulsor	У		

Course L0213: Steam Genera	itors				
Тур	Lecture				
Hrs/wk	3				
CP	5				
Workload in Hours	ndependent Study Time 108, Study Time in Lecture 42				
Lecturer	Dr. Kristin Abel-Günther				
Language	DE				
Cycle	SoSe				
Content	 Thermodynamics of steam Basic principles of steam generators Types of steam generators Fuels and combustion systems Coal pulverisers and coal drying Modes of operation Thermal analysis and design Fluid dynamics in steam generators Design of the water-steam side Construction aspects Stress analysis Feed water for steam generators Operating behaviour of steam Generators 				
Literature	 Dolezal, R.: Dampferzeugung. Springer-Verlag, 1985 Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985 Steinmüller-Taschenbuch: Dampferzeuger-Technik. Vulkan-Verlag, Essen, 1992 Kakaç, Sadık: Boilers, Evaporators and Condensers. John Wiley & Sons, New York, 1991 Stultz, S.C. and Kitto, J.B. (Ed.): Steam - its generation and use. 40th edition, The Babcock & Wilcox Company, Barbertor Ohio, USA, 1992 				

Course L0214: Steam Genera	ourse L0214: Steam Generators		
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	1		
Workload in Hours	pendent Study Time 16, Study Time in Lecture 14		
Lecturer	Dr. Kristin Abel-Günther		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses					
Title		Тур	Hrs/wk	СР	
Hydrodynamics of High Speed Water Vehicles (L1593)		Lecture	3	3	
Special Topics of Ship Propulsion (L	1589)	Lecture	3	3	
Module Responsible	Prof. Moustafa Abdel-Maksoud				
Admission Requirements	None				
Recommended Previous	Basic knowledge on ship resistance, ship	propulsion and propeller theory			
Knowledge					
Educational Objectives	After taking part successfully, students h	ave reached the following learning results			
Professional Competence					
Knowledge					
	Understand present research ques				
	Explain the present state of the ar				
	Apply given methodology to appro				
	Evaluate the limits of the present ship propulsion systems				
	 Identify possibilities to extend present methods and technologies 				
	Evaluate the feasibility of further developments				
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 s	systems under different operation conditions	by using simplified meth	ods	
	evaluate critically the investigation resu	ults of experimental or numerical investigatio	ns		
Personal Competence					
Social Competence	Students are able to				
	 solve problems in heterogeneous groups and to document the corresponding results 				
	 share new knowledge with group r 	nembers			
Autonomy	Students are able to assess their knowled	dge by means of exercises and case studies			
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	180 min				
scale					
Assignment for the	Naval Architecture and Ocean Engineerin	g: Core qualification: Elective Compulsory			
Following Curricula					
	Theoretical Mechanical Engineering: Spec	siglication Maritima Tachnalagus Flactive Com			

Instruct Instruct Instruct Image:	Course L1593: Hydrodynamics of High Speed Water Vehicles		
CP 3 Workload in Hours Independent Study Time 48, Study Time in Lecture 42 Lecturer Prof. Moustafa Abdel-Maksoud Language DE/EN Cycle SoSe Content 1. Resistance components of different high speed water vehicles . Propulsion units of high speed vehicles . Waves resistance in shallow and deep water 4. Surface effect ships (SES) 5. Hydrofoil supported vehicles 6. Semi-displacement vehicles 7. Planning vehicles 8. Slamming	Тур	Lecture	
Workload in Hours Independent Study Time 48, Study Time in Lecture 42 Lecturer Prof. Moustafa Abdel-Maksoud Language DE/EN Cycle SoSe Content 1. Resistance components of different high speed water vehicles 2. Propulsion units of high speed vehicles 3. Waves resistance in shallow and deep water 4. Surface effect ships (SES) 5. Hydrofoil supported vehicles 6. Semi-displacement vehicles 7. Planning vehicles 8. Slamming 8. Slamming	Hrs/wk		
Lecturer Prof. Moustafa Abdel-Maksoud Language DE/EN Cycle SoSe Content 1. Resistance components of different high speed water vehicles 2. Propulsion units of high speed vehicles 3. Waves resistance in shallow and deep water 4. Surface effect ships (SES) 5. Hydrofoil supported vehicles 6. Semi-displacement vehicles 7. Planning vehicles 8. Slamming 8. Slamming	СР	3	
Language DE/EN Cycle SoSe Content 1. Resistance components of different high speed water vehicles 2. Propulsion units of high speed vehicles 3. Waves resistance in shallow and deep water 4. Surface effect ships (SES) 5. Hydrofoil supported vehicles 6. Semi-displacement vehicles 7. Planning vehicles 8. Slamming 8. Slamming	Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Cycle SoSe Content 1. Resistance components of different high speed water vehicles 2. Propulsion units of high speed vehicles 3. Waves resistance in shallow and deep water 4. Surface effect ships (SES) 5. Hydrofoil supported vehicles 6. Semi-displacement vehicles 6. Semi-displacement vehicles 7. Planning vehicles 8. Slamming	Lecturer	Prof. Moustafa Abdel-Maksoud	
Content 1. Resistance components of different high speed water vehicles 2. Propulsion units of high speed vehicles 3. Waves resistance in shallow and deep water 4. Surface effect ships (SES) 5. Hydrofoil supported vehicles 6. Semi-displacement vehicles 7. Planning vehicles 8. Slamming	Language	DE/EN	
 Resistance components of different high speed water vehicles Propulsion units of high speed vehicles Waves resistance in shallow and deep water Surface effect ships (SES) Hydrofoil supported vehicles Semi-displacement vehicles Planning vehicles Slamming 	Cycle	SoSe	
	Content	 Resistance components of different high speed water vehicles Propulsion units of high speed vehicles Waves resistance in shallow and deep water Surface effect ships (SES) Hydrofoil supported vehicles Semi-displacement vehicles Planning vehicles Slamming 	
Literature Faltinsen, O. M., Hydrodynamics of High-Speed Marine Vehicles, Cambridge University Press, UK, 2006	Literature	Faltinsen, O. M., Hydrodynamics of High-Speed Marine Vehicles, Cambridge University Press, UK, 2006	

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

Module M1302: Appli	ed Humanoid Robotics		
Courses			
	-	11	
Title Applied Humanoid Robotics (L1794) Typ Project-/problem-based Learning	Hrs/wk 6	CP 6
Module Responsible	Patrick Göttsch		
Admission Requirements	None		
Recommended Previous Knowledge	 Object oriented programming; algorithms and data structures Introduction to control systems Control systems theory and design Mechanics 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence Knowledge	 Students can explain humanoid robots. Students can explain the basic concepts, relationships and methods of forward- and invers Students learn to apply basic control concepts for different tasks in humanoid robotics. 	se kinematics	
Skills	 Students can implement models for humanoid robotic systems in Matlab and C++, and us other tasks. They are capable of using models in Matlab for simulation and testing these models if new robot system. They are capable of selecting methods for solving abstract problems, for which no star apply it successfully. 	cessary with C	C++ code on the re
Personal Competence <i>Social Competence</i> <i>Autonomy</i>	 Students can develop joint solutions in mixed teams and present these. They can provide appropriate feedback to others, and constructively handle feedback on Students are able to obtain required information from provided literature sources, and lecture. 		
	They can independently define tasks and apply the appropriate means to solve them.		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Credit points	6		
Course achievement	None		
Examination	Written elaboration		
Examination duration and	5-10 pages		
scale			
Assignment for the	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulso	ory	
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compu	lsory	
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Com	apulcon	

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

Courses				
Title		Тур	Hrs/wk	СР
Automation Technology and Syster		Lecture	4	4
Automation Technology and Syster Automation Technology and Syster		Project-/problem-based Learning Recitation Section (small)	1 1	1 1
		Recitation Section (Small)	1	1
	Prof. Thorsten Schüppstuhl			
Admission Requirements	None			
Recommended Previous Knowledge	without major course assessment			
-	After taking part successfully, students have reached	the following learning results		
Professional Competence	when taking part successionly, students have reached			
Knowledge	Students			
nite medge				
	 know the characteristic components of an automatic components of automatic compo		ing of their in	teraction
	 know methods for a systematical analysis of a 			
	 have special competences in industrial robot b 	based automation systems		
Skills	Students are able to			
	analyze complex Automation tasks			
	 develop application based concepts and soluti design subsystems and integrate into one such 			
	 design subsystems and integrate into one syst investigate and evaluate safety of machinery 			
	 create simple programs for robots and program 	mmable logic controllers		
	 design of circuit for pneumatic applications 			
Personal Competence				
Social Competence	Students are able to			
	- find solutions for automation and handling tasks in	groups		
	- develop solutions in a production environment with	i qualified personnel at technical level and re	epresent deci	sions.
Autonomy	Students are able to			
	 analyze systemation tasks independently. 			
	 analyze automation tasks independently generate programs for robots and programma 	ble logic devices autonomously		
	 develop solutions for practice oriented tasks o 	- /		
	 design safety concepts for automation applica 			
	 assess consequences of their professional acti 			
	Independent Study Time 96, Study Time in Lecture 8	4		
Credit points				
Course achievement				
	Written exam			
Examination duration and	120 min			
scale				
-	International Management and Engineering: Specialis			ompulsory
Following Curricula	Product Development, Materials and Production: Spe		ompulsory	
	Product Development, Materials and Production: Spe			
	Product Development, Materials and Production: Spe Theoretical Mechanical Engineering: Technical Comp			
	Theoretical Mechanical Engineering: Technical Comp Theoretical Mechanical Engineering: Specialisation Pl		Commulation	

Course L2329: Automation T	ourse 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 T	urse 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
CP	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

Courses				
Title		Тур	Hrs/wk	СР
Advanced Topics in Vibration (L174	3)	Project-/problem-based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Vibration Theory			
Knowledge				
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts of Ac	vanced Vibrations and to develop and resea	arch new terms	and concepts.
Skills	Students are able to apply existing methods and procesures of	f Advanced Vibrations and to develop novel	methods and p	procedures.
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks individua	ly and to identify and follow up novel resear	rch tasks by the	mselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Mechatronics: Specialisation System Design: Elective Co	mpulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Rol	otics: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Electiv	e Compulsory		
	Theoretical Mechanical Engineering: Technical Complem	entary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Produ	ct Development and Production: Elective	e 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	

Courses				
Title		Тур	Hrs/wk	СР
Artificial Joint Replacement (L1306)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgica	al techniques is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence				
Knowledge	The students can name the different kinds	of artificial limbs.		
Chille	The students can explain the advantages	and disadvantages of different kinds of one	lanrathacac	
SKIIIS	The students can explain the advantages	and disadvantages of different kinds of end	ioprocheses.	
Personal Competence				
Social Competence	The students are able to discuss issues rel	ated to endoprothese with student mates a	and the teachers.	
Autonomy	The students are able to acquire informati	on on their own. They can also judge the in	formation with respect to	ite crodibility
Autonomy		on on their own. They can also judge the in	normation with respect to	its creationity.
Workload in Hours	Independent Study Time 62, Study Time in	n Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineerin	g: Specialisation II. Process Engineering an	d Biotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano and	Hybrid Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Art	ificial Organs and Regenerative Medicine: I	Elective Compulsory	
	Biomedical Engineering: Specialisation Imp	plants and Endoprostheses: Compulsory		
		dical Technology and Control Theory: Elect		
	• • •	nagement and Business Administration: Ele	ective Compulsory	
	Orientation Studies: Core qualification: Ele			
	• •	nical Complementary Course: Elective Com alisation Bio- and Medical Technology: Elec		

Course L1306: Artificial Joint	Replacement
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	Inhalt (deutsch)
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes)
	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)
Literature	Literatur:
	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

Courses				
Title		Тур	Hrs/wk	СР
Design Optimization and Probabilis	tic Approaches in Structural Analysis (L1873)	Lecture	2	3
Design Optimization and Probabilis	tic Approaches in Structural Analysis (L1874)	Recitation Section (large)	2	3
Module Responsible	Prof. Benedikt Kriegesmann			
Admission Requirements	None			
Recommended Previous				
Knowledge	Technical mechanics			
	Higher math			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
	Design optimization			
	Gradient based methods			
	Genetic algorithms			
	 Optimization with constraints 			
	Topology optimization Deliability analysis			
	Reliability analysis Stachastic basiss			
	 Stochastic basics Monte Carlo methods 			
	 Semi-analytic approaches 			
	 robust design optimization 			
	Robust design optimization			
	 Coupling of design optimization and relia 	ability analysis		
Skills	 Application of optimization algorithms and prol 	abilistic methods in the design of struct	uros	
	 Programming with Matlab 	babilistic methods in the design of struct	ures	
	 Implementation of algorithms 			
	Debugging			
	202039119			
Personal Competence				
Social Competence	Team work			
	 Oral explanation of the the work 			
Autonomy	 Application of methods learned in the framework 	rk of a home work		
	 Familiarizing with source code provided 			
	 Description of approaches and results 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement				
Examination	Written elaboration			
Examination duration and	10 pages			
scale				
Assignment for the	Aircraft Systems Engineering: Core qualification: Elect	tive Compulsory		
Following Curricula	Product Development, Materials and Production: Core	qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Compl	ementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualification	n [.] Elective Compulsory		

Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	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:
Literature	 Arora, Jasbir. Introduction to Optimum Design. 3rd ed. Boston, MA: Academic Press, 2011. Haldar, A., and S. Mahadevan. Probability, Reliability, and Statistical Methods in Engineering Design. John Wiley & Sons New York/Chichester, UK, 2000.

Course L1874: Design Optim	urse L1874: Design Optimization and Probabilistic Approaches in Structural Analysis		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	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					
Title		Тур	Hrs/wk	СР	
Compilers for Embedded Systems		Lecture	3	4	
Compilers for Embedded Systems		Project-/problem-based Learning	1	2	
Module Responsible	Prof. Heiko Falk				
Admission Requirements	None				
Recommended Previous	Module "Embedded Systems"				
Knowledge	C/C++ Programming skills				
Educational Objectives	After taking part successfully, students have	reached the following learning results			
Professional Competence					
Knowledge	The relevance of embedded systems increas	es from year to year. Within such systems, the amo	ount of softwa	re to be executed	
		ue to its lower costs and higher flexibility. Because			
		d application-specific processors are deployed. S			
		ve to generate code of highest quality. After the su	ccessful attend	dance of this cours	
	the students are able				
	 to illustrate the structure and organiza 	tion of such compilers,			
	 to indistrate 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 exploit 	ted effectively.			
	Since compilers for embedded systems often have to entimize for multiple objectives (e.g., average, or worst case execution time				
	Since compilers for embedded systems often have to optimize for multiple objectives (e.g., average- or worst-case ex- energy dissipation, code size), the students learn to evaluate the influence of optimizations on these different criteria				
	energy dissipation, code size), the students is	earn to evaluate the influence of optimizations on the	nese different	criteria.	
Skills		udents shall be able to translate high-level program			
	be enabled to assess which kind of code optimization should be applied most effectively at which abstraction level (e.g., source o				
	assembly code) within a compiler.				
	While attending the labs, the students will lea	arn to implement a fully functional compiler includir	ng optimizatior	15.	
Porconal Competence					
Personal Competence	Students are able to solve similar problems	lone or in a group and to present the results accord	lingly		
Social competence	Students are able to solve similar problems a	none of in a group and to present the results accord	migiy.		
Autonomy	Students are able to acquire new knowledge	from specific literature and to associate this knowle	edge with othe	r classes.	
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	30 min				
scale					
Assignment for the	Computer Science: Specialisation I. Compute	r and Software Engineering: Elective Compulsory			
Following Curricula	Electrical Engineering: Specialisation Informa	tion and Communication Systems: Elective Compul	sory		
	Aircraft Systems Engineering: Core qualification	ion: Elective Compulsory			
	Mechatronics: Specialisation Intelligent Syste	ms and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Design:	Elective Compulsory			
	Mechatronics: Technical Complementary Cou	rse: Elective Compulsory			
	Theoretical Mechanical Engineering: Technica	al Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialis	sation Robotics and Computer Science: Elective Cor	npulsory		

Course L1692: Compilers for	Embedded Systems
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Heiko Falk
Language	DE/EN
Cycle	SoSe
Content	 Introduction and Motivation Compilers for Embedded Systems - Requirements and Dependencies Internal Structure of Compilers Pre-Pass Optimizations HIR Optimizations and Transformations Code Generation LIR Optimizations and Transformations Register Allocation WCET-Aware Compilation Outlook
Literature	 Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2 nd Edition, Springer, 2012. Steven S. Muchnick. Advanced Compiler Design and Implementation. Morgan Kaufmann, 1997. Andrew W. Appel. Modern compiler implementation in C. Oxford University Press, 1998.

Course L1693: Compilers for	Course L1693: Compilers for Embedded Systems		
Тур	Project-/problem-based Learning		
Hrs/wk	1		
СР	2		
Workload in Hours	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		

	ture and properties of fibre-polyme			
Courses				
Fitle		Тур	Hrs/wk	СР
Structure and properties of fibre-po	lymer-composites (L1894)	Lecture	2	3
Structure and properties of fibre-po		Project-/problem-based Learning	2	2
Structure and properties of fibre-po	lymer-composites (L2613)	Recitation Section (large)	1	1
Module Responsible	Prof. Bodo Fiedler			
Admission Requirements	None			
	Basics: chemistry / physics / materials science			
Knowledge				
Educational Objectives	After taking part successfully, students have reached	I the following learning results		
Professional Competence				
Knowledge	Students can use the knowledge of fiber-reinforced	composites (FRP) and its constituents to p	lay (fiber / m	atrix) and define (
	necessary testing and analysis.			
	They can explain the complex relationships structure	-property relationship and		
	the interactions of chemical structure of the poly		fiber types,	including to expl
	neighboring contexts (e.g. sustainability, environment	ital protection).		
Skills	Students are capable of			
	using standardized calculation methods in a	given context to mechanical properties (m	odulus, strenç	gth) to calculate a
	evaluate the different materials.		.1	
	approximate sizing using the network theory of a second size of the second size of t			
	 selecting appropriate solutions for mechanical 	recycling problems and sizing example stim	ness, corrosio	in resistance.
Personal Competence				
Social Competence	Students can			
	arrive at funded work results in heterogenius provide appropriate feedback and handle feed			
	 provide appropriate feedback and handle feed 	back on their own performance constructive	ery.	
Autonomy	Students are able to			
Autonomy				
	- assess their own strengths and weaknesses.			
	- assess their own state of learning in specific terms	ing in specific terms and to define further work steps on this basis.		
	- 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.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture	70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Energy Systems: Core qualification: Elective Compute	sory		
Following Curricula	Aircraft Systems Engineering: Core qualification: Elec	tive Compulsory		
	International Management and Engineering: Speciali	sation II. Product Development and Production	on: Elective Co	ompulsory
	Materials Science: Specialisation Engineering Materia	ls: Elective Compulsory		
	Mechanical Engineering and Management: Core qual	ification: Compulsory		
	Product Development, Materials and Production: Spe	cialisation Product Development: Elective Co	ompulsory	
	Product Development, Materials and Production: Spe	cialisation Production: Elective Compulsory		
	Product Development, Materials and Production: Spe			
	Renewable Energies: Specialisation Bioenergy System			
	Renewable Energies: Specialisation Wind Energy Sys			
	Renewable Energies: Specialisation Solar Energy Sys			
	Theoretical Mechanical Engineering: Specialisation M			
	Theoretical Mechanical Engineering: Technical Comp	iementary Course: Elective Compulsory		

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

Course L2614: Structure and	urse L2614: Structure and properties of fibre-polymer-composites		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
CP	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Bodo Fiedler		
Language	DE/EN		
Cycle	SoSe		
Content			
Literature			

Course L2613: Structure and	ourse L2613: Structure and properties of fibre-polymer-composites		
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Bodo Fiedler		
Language	EN		
Cycle	SoSe		
Content			
Literature			

Module M1306: Contr	ol Lab C			
_				
Courses				
Title		Тур	Hrs/wk	СР
Control Lab IX (L1836)		Practical Course	1	1
Control Lab VII (L1834) Control Lab VIII (L1835)		Practical Course Practical Course	1	1
Module Responsible	Prof Harbort Warpar	Flactical Course	1	I
Admission Requirements				
Recommended Previous	None			
Knowledge	State space methods			
Knowledge	LQG control			
	H2 and H-infinity optimal control			
	 uncertain plant models and robust compared to the second se	control		
	LPV control			
Educational Objectives	After taking part successfully, students hav	ve reached the following learning results		
Professional Competence	Arter taking part successivity, stadents hav	reactice the following learning results		
Knowledge				
Knowledge	Students can explain the difference	between validation of a control lop in simulation	n and experimental v	validation
Skills				
SKIIIS	 Students are capable of applying I 	basic system identification tools (Matlab Syst	tem Identification To	olbox) to identify
	dynamic model that can be used for	controller synthesis		
	• They are capable of using standard	d software tools (Matlab Control Toolbox) for	the design and imp	lementation of LQ
	controllers			
	 They are capable of using standard 	software tools (Matlab Robust Control Toolbox)	for the mixed-sensit	ivity design and the
	implementation of H-infinity optimal	controllers		
	They are capable of representing mo	odel uncertainty, and of designing and impleme	enting a robust contro	oller
	They are capable of using standard s	software tools (Matlab Robust Control Toolbox)	for the design and th	e implementation o
	LPV gain-scheduled controllers			
Personal Competence				
Social Competence				
Social Competence	Students can work in teams to condu	uct experiments and document the results		
. .				
Autonomy	• Students can independently carry or	ut simulation studies to design and validate cor	ntrol loops	
		1		
	Independent Study Time 48, Study Time in	Lecture 42		
Credit points Course achievement				
	None Written elaboration			
Examination duration and				
scale	-			
Assignment for the	Electrical Engineering: Specialisation Contr	rol and Power Systems Engineering: Elective Co	mpulsory	
Following Curricula			,	
	Mechatronics: Specialisation System Design			
	Theoretical Mechanical Engineering: Core of			
		nical Complementary Course: Elective Compulso	orv	
		, construction and compared		

Course L1836: Control Lab I)	urse L1836: Control Lab IX		
Тур	Practical Course		
Hrs/wk	1		
СР	1		
Workload in Hours	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 V	irse L1834: Control Lab VII		
Тур	Practical Course		
Hrs/wk	1		
СР	1		
Workload in Hours	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: Control Lab V	III
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	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

Courses				
Title		Тур	Hrs/wk	СР
Numerical Methods in Ship Design	L1271)	Lecture	2	4
Numerical Methods in Ship Design	L1709)	Project-/problem-based Learning	2	2
Module Responsible	Prof. Stefan Krüger			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follow	ving learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	45 min			
scale				
Assignment for the	Naval Architecture and Ocean Engineering: Core gualification:	Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Complementary	1 5		
	Theoretical Mechanical Engineering: Specialisation Maritime Te			

Course L1271: Numerical Me	thods in Ship Design
Тур	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	SoSe
Content	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
Literature	Mass distributions and longitudinal strength Hullform Design by CFD- techniques Propulsor and Rudder Design by CFD Techniques Skript zur Vorlesung.

Course L1709: Numerical Me	Course L1709: Numerical Methods in Ship Design		
Тур	Project-/problem-based Learning		
Hrs/wk			
CP	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		

Courses						
Title			-	Тур	Hrs/wk	СР
ntelligent Systems in Medicine (L0				Lecture	2	3
ntelligent Systems in Medicine (L0				Project Seminar	2	2
Intelligent Systems in Medicine (LO				Recitation Section (small)	1	1
Module Responsible		aefer				
Admission Requirements	None					
Recommended Previous Knowledge	 principles of it 	math (algebra, analysis/ca	alculus)			
Knowledge	 principles of s 	stochastics				
	 principles of 	orogramming, Java/C++ a	and R/Matlab			
	 advanced pro 	gramming skills				
Educational Objectives	After taking part su	ccessfully, students have	reached the following	g learning results		
Professional Competence						
Knowledge	The students are al	ole to analyze and solve o	clinical treatment pla	anning and decision support	problems using	methods for search
	optimization, and pl	anning. They are able to	explain methods for	classification and their resp	ective advantage	s and disadvantag
	in clinical contexts.	The students can compar	e different methods	for representing medical kn	owledge. They ca	an evaluate metho
	in the context of cli	nical data and explain ch	nallenges due to the	clinical nature of the data a	and its acquisition	n and due to priva
	and safety requirem	ients.				
Skills	Ils The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can ass the methods based on actual patient data and evaluate the implemented methods.				ion. They can asse	
Personal Competence						
Social Competence	The students discus	s the results of other grou	ips, provide helpful f	eedback and can incoorpora	ite feedback into	their work.
Autonomy	Autonomy The students can reflect their knowledge and document the results of their work. They can present the results in				lts in an appropria	
	manner.					
Workload in Hours	Independent Study	Time 110, Study Time in I	ecture 70			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	Yes 10 %	Presentation				
	Yes 10 %	Written elaboration				
Examination	Written exam					
Examination duration and	90 minutes					
scale						
Assignment for the	Computer Science:	Specialisation II: Intelliger	nce Engineering: Elec	tive Compulsory		
Following Curricula	-	ng: Specialisation Medical	•••			
				ods in Biomedical Imaging: (Compulsory	
		alisation Intelligent Syste			2	
	_			nerative Medicine: Elective (Lompulsory	
	5	ring: Specialisation Implan				
	-			ontrol Theory: Elective Com		
	-			Administration: Elective Co	mpulsory	
				ourse: Elective Compulsory	nulcon.	
	meorecical Mechan	car Engineering: Specialis	auon bio- dhu Mealc	al Technology: Elective Com	10015019	

Course L0331: Intelligent Sy	stems in Medicine				
Тур	Lecture				
Hrs/wk	2				
CP	3				
Workload in Hours	lependent Study Time 62, Study Time in Lecture 28				
Lecturer	Prof. Alexander Schlaefer				
Language	EN				
Cycle	WiSe				
Content	 methods for search, optimization, planning, classification, regression and prediction in a clinical context representation of medical knowledge understanding challenges due to clinical and patient related data and data acquisition The students will work in groups to apply the methods introduced during the lecture using problem based learning. 				
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 Sy	urse L0334: Intelligent Systems in Medicine			
Тур	Project Seminar			
Hrs/wk	2			
СР	2			
Workload in Hours	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 Sy	ourse 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		

Courses						
Title			Тур	Hrs/wk	СР	
Application of Innovative CFD Methods in Research and Development (L0239)			Lecture	2	3	
Application of Innovative CFD Meth		velopment (L1685)	Recitation Section (small)	2	3	
Module Responsible	-					
Admission Requirements	None					
	Attendance of a comp	putational fluid dynamics cour	rse (CFD1/CFD2)			
Knowledge	Competent knowledge of numerical analysis in addition to general and computational thermo/fluid dynamics					
Educational Objectives	After taking part successfully, students have reached the following learning results					
Professional Competence						
Knowledge	Knowledge Student can explain the theoretical background of different CFD strategies (e.g. Lattice-Boltzmann, Smo				Smoothed Partic	
Hydrodynamics, Finite-Volume methods) and describe the fundamentals of simulation-based optimisation.						
Skille	Student is able to identify an appropriate CED based solution strategy on a justified basis					
Personal Competence	Student is able to identify an appropriate CFD-based solution strategy on a jusitfied basis.					
	Student should practi	Student should practice her/his team-working abilities, learn to lead team sessions and present solutions to experts.				
	Student should be able to structure and perform a simulation-based project independently,					
· · · · · · · · · · · · · · · · · · ·		Independent Study Time 124, Study Time in Lecture 56				
Credit points						
Course achievement	Compulsory Bonus	Form	Description			
	Yes 20 %	Written elaboration				
Examination	Oral exam					
Examination duration and	30 min					
scale						
Assignment for the	Energy Systems: Core	e qualification: Elective Comp	ulsory			
Following Curricula	Naval Architecture ar	nd Ocean Engineering: Core q	ualification: Elective Compulsory			
	Ship and Offshore Te	chnology: Core qualification: E	Elective Compulsory			
	Theoretical Mechanic	al Engineering: Technical Con	nplementary Course: Elective Compulsory			
		• • •	Simulation Technology: Elective Compuls	ory		
	Process Engineering:	Specialisation Process Engine	ering: Elective Compulsory			

Course L0239: Application of	f 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	Course L1685: Application of Innovative CFD Methods in Research and Development		
Тур	Recitation Section (small)		
Hrs/wk			
CP	3		
Workload in Hours	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		

Courses				
Courses				
Title Steam turbines in energy, environn	ental and Power Train Engineering (L1286)	Typ Lecture	Hrs/wk 3	CP 5
	nental and Power Train Engineering (L1280)	Recitation Section (small)	1	1
	Dr. Christian Scharfetter			_
-	None			
Admission Requirements Recommended Previous	None			
Knowledge				
Knowneuge	"Gas and Steam Power Plants"			
	"Technical Thermodynamics I & II"			
	"Fluid Mechanics"			
	After taking part successfully, students have reached	I the following learning results		
Professional Competence				
Knowledge	After successful completion of the module the studer	nts must be in a position to:		
	 name and identify the various parts and const 	ructive groups of steam turbines		
	describe and explain the key operating condit	ons for the application of steam turbines	5	
	classify different construction types and differ	entiate among steam turbines according	to size and operation	ating ranges
	 describe the thermodynamic processes and the second second	e constructive and operational repercus	sions resulting fro	om the latter
	calculate thermodynamically a turbine stage a			
	 calculate or estimate and further evaluate sec 			
	outline diagrams describing the operating ran			
	 investigate the constructive aspects and constructive 	levelop from the thermodynamic requ	urements the re	equired construct
	characteristics	stics of different turking turgs		
	 discuss and argue on the operation characteri evaluate thermodynamically the integration o 			
	• evaluate thermodynamically the integration of	different turbine designs in fleat cycles.		
Skills	In the module the students learn the fundamental a	pproaches and methods for the design a	and operational e	valuation of comp
	plant, and gain in particular confidence in seeking op	timisations. They specifically:		
	obtain the ability to analyse the potential o	f various energy sources that can be	utilised thermody	vnamically from
	energetic-economic and technical viewpoints	i vanous energy sources that can be		ynanneany, nonn y
	 can evaluate the performance and technica 	I limitations in using various energy s	ources, for supp	lying base load a
	balancing reserve power to the electricity grid	5 57		, ,
	• on the basis of the impact of power plant	operation on the integrity of compone	ents, can describ	e the precaution
	principles for damage prevention			
	can describe the key requirements for the I	Management and Design of Thermal Po	ower Plants, base	ed on the overrid
	demands imposed by various legislative frame	eworks.		
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 w	orking of a complex theme whilst consid	ering various aco	ects They also les
Autonomy	how to combine independent functions in a system.	states a complex area winist consid		
	The students become the ability to gain independent	ly knowledge and transfer it also to new	problem solving.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	Energy and Environmental Engineering: Specialisatio	n Energy Engineering: Elective Compuls	ory	
Following Curricula	International Management and Engineering: Speciali		-	Compulsory
-	Theoretical Mechanical Engineering: Technical Comp		-	-

Тур	Lecture	
Hrs/wk	3	
CP	5	
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42	
Lecturer	Dr. Christian Scharfetter	
Language	DE	
Cycle	WiSe	
Literature	 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 Connection to thermal and electrical energy networks, interfaces Conventional and regenerative power plant concepts, drive technology Analysis of the global energy supply market Applications in conventional and regenerative power plants Different power plant concepts and their influence on the steam turbine (engine and gat turbine power plants with waste heat utilization, geothermal energy, solar thermal energy biomass, biogas, waste incineration). Classic combined heat and power generation as a combined product of the manufacturir industry Impact of change in the energy market, operating profiles Applications in drive technology Operating and maintenance concepts The lecture will be deepened by means of examples, tasks and two excursions Traupel, W.: Thermische Turbomaschinen. Berlin u. a., Springer (TUB HH: Signatur MSI-105) Menny, K.: Strömungsmaschinen: hydraulische und thermische Kraft- und Arbeitsmaschinen. Ausgabe: 5. Wiesbade Teubner, 2006 (TUB HH: Signatur MSI-109) Bohl, W.: Aufbau und Wirkungsweise. Ausgabe 6. Wirzburg, Vogel, 1999 (TUB HH: Signatur MSI-109) 	

Course L1287: Steam turbines in energy, environmental and Power Train Engineering		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	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	

Courses				
Title		Тур	Hrs/wk	СР
Thermal Engergy Systems (L0023)		Lecture	3	5
Thermal Engergy Systems (L0024)		Recitation Section (large)	1	1
Module Responsible				
Admission Requirements				
	Technical Thermodynamics I, II, Fluid Dynamics	s, Heat Transfer		
Knowledge				
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence				
Knowledge	Students know the different energy conversion			
	increased knowledge in heat and mass transfe			
	German energy saving code and other technic			
	industrial area and how to control such hea			
	temperatures in a furnace. They have the ba			
	conduct the flue gases into the atmosphere. The	ney are able to model thermodynamic systems	with object orien	ited languages.
Skills	Students are able to calculate the heating dem			
	able to calculate a pipeline network and have			
	Modelica programs and can transfer research	knowledge into practice. They are able to p	erform scientific	work in the field
	thermal engineering.			
Personal Competence				
Social Competence	The students are able to discuss in small group	s and develop an approach.		
Autonomv	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use			
2	knowledge in practice.			2
Workload in Hours	Independent Study Time 124, Study Time in Le	ecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Bioprocess Engineering: Specialisation A - Gen	eral Bioprocess Engineering: Elective Compulso	ry	
Following Curricula	Energy and Environmental Engineering: Specia	lisation Energy Engineering: Elective Compulso	ry	
	Energy Systems: Specialisation Energy System	s: Compulsory		
	Energy Systems: Specialisation Marine Enginee	•		
	International Management and Engineering: Sp	pecialisation II. Energy and Environmental Engir	neering: Elective	Compulsory
	Product Development, Materials and Production			
	Renewable Energies: Core qualification: Compu	•		
	Theoretical Mechanical Engineering: Specialisa			
	Theoretical Mechanical Engineering: Technical	Complementary Course: Elective Compulsory		

Course L0023: Thermal Enge	rgy Systems
Тур	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	NN
Language	DE
Cycle	WiSe
Content	1. Introduction
	 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 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 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 Laws and standards 5.1 Buildings 5.2 Industrial plants
Literature	 Schmitz, G.: Klimaanlagen, Skript zur Vorlesung VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013 Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009 Recknagel, H.; Sprenger, E.; Schrammek, ER.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013

Course L0024: Thermal Enge	urse 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	NN		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses						
Title				Тур	Hrs/wk	СР
Energy from the Ocean (L0002) Fluid Mechanics II (L0001)				Lecture Lecture	2	2
	Deef Misheel Cabl			Lecture	Z	4
Module Responsible Admission Requirements		uter				
Recommended Previous		odynamik I II				
	Wärme- und Stoffi					
Kilowieuge	Warme- and Stone	abertragang				
Educational Objectives	After taking part s	uccessfully, students	have reached the fol	lowing learning results		
Professional Competence						
Knowledge	The students are a	able to describe diffe	rent applications of flu	uid mechanics for the fie	eld of Renewable Energies.	They are able to u
	the fundamentals	of fluid mechanics fo	r calculations of certa	in engineering problem	s in the field of ocean ener	rgy. The students a
	able to estimate if a problem can be solved with an analytical solution and what kind of alternative possibilities are available				es are available (e	
	self-similarity, em	pirical solutions, num	erical methods).			
Skills	Students are able	to use the governing	equations of Fluid D	vnamics for the design	of technical processes. Esg	pecially they are al
	Its Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are to formulate momentum and mass balances to optimize the hydrodynamics of technical processes. They are able to transit					
	verbal formulated message into an abstract formal procedure.					
D						
Personal Competence	The shudents are					
Social Competence	The students are able to discuss a given problem in small groups and to develop an approach. They are able to solve a proble within a team, to prepare a poster with the results and to present the poster.					
	within a team, to p	orepare a poster with	The results and to pr	esent the poster.		
Autonomy	Students are able	to define independe	ntly tasks for problem	s related to fluid mecha	anics. They are able to wor	rk out the knowled
	that is necessary t	o solve the problem	by themselves on the	basis of the existing kn	owledge from the lecture.	
Workload in Hours	Independent Stud	v Time 124. Studv Ti	me in Lecture 56			
Credit points		, ,				
Course achievement	Compulsory Bonus	Form	Descriptio	ı		
	Yes 10 %	Group discussion	n			
Examination	Written exam					
Examination duration and	3h					
scale						
Assignment for the	Energy Systems: 0	Core qualification: Ele	ective Compulsory			
Following Curricula			•	. Renewable Energy: Ele	ective Compulsory	
	-	es: Core qualification				
				ystems: Elective Compu	•	
	Theoretical Mecha	nical Engineering: Te	chnical Complementa	ary Course: Elective Con	npulsory	

Course L0002: Energy from t	he 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	 Introduction to ocean energy conversion Wave properties Linear wave theory Nonlinear wave theory Irregular waves Wave energy Refraction, reflection and diffraction of waves Wave energy converters Overview of the different technologies Methods for design and calculation Ocean current turbine
Literature	 Cruz, J., Ocean wave energy, Springer Series in Green Energy and Technology, UK, 2008. Brooke, J., Wave energy conversion, Elsevier, 2003. McCormick, M.E., Ocean wave energy conversion, Courier Dover Publications, USA, 2013. Falnes, J., Ocean waves and oscillating systems, Cambridge University Press,UK, 2002. Charlier, R. H., Charles, W. F., Ocean energy. Tide and tidal Power. Berlin, Heidelberg, 2009. Clauss, G. F., Lehmann, E., Östergaard, C., Offshore Structures. Volume 1, Conceptual Design. Springer-Verlag, Berlin 1992

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

Courses				
Title		Тур	Hrs/wk	СР
Aircraft Energy Systems (L0735)		Lecture	3	4
Aircraft Energy Systems (L0739)		Recitation Section (large)	2	2
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge	. Mathanatia			
	Mathematics			
	Mechanics The sum of the			
	Thermodynamics			
	Electrical Engineering			
	Hydraulics			
	Control Systems			
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence				
Knowledge	Students are able to:			
	Describe essential components and des	ign points of hydraulic, electrical and high-lift s	vstems	
	 Give an overview of the functionality of 		ysterns	
	 Explain the need for high-lift systems su 			
	 Assess the challenge during the design 			
	• Assess the chancing during the design	or supply systems of an anerale		
CI-ill-	Students are able to:			
SKIIIS				
	 Design hydraulic and electric supply sys 	tems of aircrafts		
	 Design high-lift systems of aircrafts 			
	Analyze the thermodynamic behaviour of	of air conditioning systems		
Personal Competence				
	Students are able to:			
Social competence				
	 Perform system design in groups and pr 	esent and discuss results		
Autonomy	Students are able to:			
	Reflect the contents of lectures autonom	nously		
Workload in Hours	Independent Study Time 110, Study Time in Le	acture 70		
Credit points				
Course achievement				
	Written exam			
Examination duration and				
scale				
	Energy Systems: Specialisation Energy System	s: Elective Compulsory		
-	Aircraft Systems Engineering: Core qualificatio			
		pecialisation II. Aviation Systems: Elective Com	oulsory	
	5 5 5 1	n: Specialisation Product Development: Elective	3	
		n: Specialisation Production: Elective Compulso		
		n: Specialisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical		,	
	Theoretical Mechanical Engineering: Specialisa			

Course L0735: Aircraft Energ	av Svetame
-	Lecture
Hrs/wk	
CP	
	Independent Study Time 78, Study Time in Lecture 42
	Prof. Frank Thielecke
Language	
Cycle	WiSe
Content	 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) Electric Energy Systems (Generators; constant-speed-drives; DC and AC converters; electrical power distribution; bus systems; monitoring; load analysis) High Lift Systems (Principles; investigation of loads and system actuation power; principles and sizing of actuation and positioning systems; safety requirements and devices) Environmental Control Systems (Thermodynamic analysis; expansion and compression cooling systems; control strategies; cabin pressure control systems)
Literature	 Moir, Seabridge: Aircraft Systems Green: Aircraft Hydraulic Systems Torenbek: Synthesis of Subsonic Airplane Design SAE1991: ARP; Air Conditioning Systems for Subsonic Airplanes

Course L0739: Aircraft Energ	ourse L0739: Aircraft Energy Systems		
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		

Courses						
Title				Тур	Hrs/wk	СР
Aircraft Design I (Design of Transport Aircraft) (L0820)				Lecture	3	3
Aircraft Design I (Design of Transpo	1			Recitation Section (large)	2	3
Module Responsible						
Admission Requirements	None					
Recommended Previous	Bachelor Mech	n. Eng.				
Knowledge	Bachelor Traff	•				
	Vordiplom Mee					
	Module Air Tra	•				
	riodale / in fie	insport of stering				
Educational Objectives	After taking part suc	cessfully, students hav	ve reached the following	g learning results		
Professional Competence						
Knowledge		ante a dia a sfinte anata	al a seal a finil a factor fit al a str			
		• •	d and civil aircraft desig	-		
	-		nd contributions of the			
	3. Impact of the relevant design parameter on the civil aircraft design					
	4. Introduction of the principle design methods					
Skills	Understanding and application of design and calculation methods					
	Understanding of inte	erdisciplinary and inte	grative interdependenc	ies		
Personal Competence						
	Working in interdisci	Working in interdisciplinary teams				
	5					
	Communication					
Δυτοποπγ	Organization of work	flows and -strategies				
Workload in Hours	-	ime 110, Study Time i	in Locturo 70			
Credit points		ine 110, Study fille f	III Lecture 70			
Course achievement		Form	Description			
course achievement	No 10 %	Attestation	-	einer Konzeptauslegung für	ein Verkehrsflug	zeua
Examination	Written exam					
Examination duration and						
scale	200 11111					
Assignment for the	Aircraft Systems Eng	ineering: Core qualific	ation: Compulsory			
Following Curricula				ition Systems: Elective Com	nulsony	
ronowing curricula	-			oduct Development: Elective		
	-			oduct Development: Elective		
				oduct Development: Elective oduction: Elective Compulso		
			·	ouction: Elective Compulsory	'' y	
		cal Engineering: Techn				

Тур	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Volker Gollnick, Jens Thöben
Language	DE
Cycle	WiSe
Content	Introduction into the aircraft design process
	1. Introduction/process of aircraft design/various aircraft configurations
	2. Requirements and design objectives, main design parameter (u.a. payload-range-diagramme)
	3. Statistical methods in overall aircraft design/data base methods
	4. Cabin design (fuselage sizing, cabin interior, loading systems)
	5. Principles of aerodynamic aircraft design (polar, geometry, 2D/3D aerodynamics)
	6. Wing Design
	7. Tail wings and landing gear
	8. Principles of engine design and integration
	9. Flight performance in cruise
	10. Take off and landing field length
	11. Loads and V-n-diagramme
	12. Operating cost calculation
Literature	J. Roskam: "Airplane Design"
	D.P. Raymer: "Aircraft Design - A Conceptual Approach"
	J.P. Fielding: "Introduction to Aircraft Design"
	Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"

Course L0834: Aircraft Desig	ourse L0834: Aircraft Design I (Design of Transport Aircraft)		
Тур	Recitation Section (large)		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Volker Gollnick, Jens Thöben		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses Typ Hrs/wk CP Exercise installation on Ships (1153) Recitation Section (large) 1 1 Marine Engineering (1150) Recitation Section (large) 1 1 Marine Engineering (1150) Recitation Section (large) 1 1 Module Aesponshile Port Christopher Friedrich Wirz Recitation Section (large) 1 1 Module Aesponshile Port Christopher Friedrich Wirz Recitation Section (large) 1 1 Module Aesponshile Port Christopher Friedrich Wirz Recitation Section (large) 1 1 Module Aesponshile Port Excessfully, students have reached the following learning results 1 1 Educational Objectives After taking part successfully, students have reached the following learning results 1 1 Professional Competence Knowledge The students are able to describe the state-of-the-art regarding the wide range of propulsion rowners, describe pape, correlations with the specific technical terms in Geman and English. The students are able to cample approximation on the pape approximation and english. The students are able to anno poperation problem with related disciplines. Students are able to anno poperation and distribution in isolated gird, wave generator systems on ships, and name req					
 Liectroal installation on Ships (11331) Liectroal on Ships (11332) Rectation Scient (argo) 1 1 Rectation on Ships (11357) Rectation Section (argo) 1 1 1 Rectation Section (argo) 1 1 Rectation Section (argo) 1 1 1 Rectation Section (argo) 1 1	Courses				
Electrical Isolation on Sing (L1529) Recitation Section (large) 1 1 Marine Engineering (L1569) Pof. Christopher Friedrich Wirz Recitation Section (large) 1 1 Module Responsible Pof. Christopher Friedrich Wirz Recitation Section (large) 1 1 Admission Requirements None None Image: Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Admission Requirements None None Image: Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Admission Requirements None None Image: Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Admission Requirements Mone None Image: Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Admission Requirements Mone Image: Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Education Competence After taking part successfully, students have reached the following learning results Image: Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Advisor Printipe Christopher Friedrich Wirz Advisor Printipe Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Friedrich Statup	Fitle		Тур	Hrs/wk	СР
Nomine Engineering (11550) Lecture 2 2 Marine Engineering (11570) Reclation Section (large) 1 1 Module Responsible Prof. Christopher Friedrich Wirz 1 1 Admission Requirements None Image: Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Recommended Previous Knowledge Image: Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Professional Competence Freissenial Objectives After taking part successfully, students have reached the following learning results Professional Competence Freissenial Christopher Friedrich Wirz Image: Christopher Friedrich Wirz Admission Requirements None Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence The students are able to describe the state-of-the-art regarding the wide range of propulsion systems, exploying preversion and distribution in isolated grids, wave generator systems on ships, and name requirements for netw protection, selectivity and operation board ships. They are further able to assess, analyse and solve technical and operation problems with propulsion and avait part ships. Skiffs The students are able to communicate and cooperate in a professional environment in the shipbuilding and component sup industry. <tr< td=""><td>Electrical Installation on Ships (L15</td><td>31)</td><td>Lecture</td><td>2</td><td>2</td></tr<>	Electrical Installation on Ships (L15	31)	Lecture	2	2
Narine Empireeing (11570) Recitation Section (large) 1 Module Responsible Prior Christopher Friedrich Wirz Admission Requirements None Recommended Previous Intervious Educational Objectives After taking part successfully, students have reached the following learning results Professional Competerce Intervious Knowledge The students are able to describe the state-of-the-art regarding the wide range of propulsion components on ships and apply it the work describe complex correlations with the specific technical terms in German and English. The students are able to describe complex correlations on the design of supply networks and to the electric equipment in isolated networks, as e.g. onboard ships, offshore units, factories and emergency power supply systems, expl power generation and distribution in isolated grids, wave generator systems on ships, and name requirements for netw protection, selectivity and operational monitoring. Skiffit The students are skilled to employ basic and detail knowledge regarding reciprocating machinery, their selection and operation board ships. They are further able to assess, analyse and solve technical and operational problems multiplem into control with related disciplines. Students are able to communicate and cooperate in a professional environment in the shipbuilding and component sup industry. Autonomi The students are able to communicate and cooperate in a professional environment in the shipbuilding and component sup industry. Autonomi The students ar	Electrical Installation on Ships (L15	32)	Recitation Section (large)	1	1
Module Responsible Prof. Christopher Friedrich Wirz Admission Requirements None Recommended Previous Interview Knowledge After taking part successfully, students have reached the following learning results Professional Competence Knowledge Knowledge The students are able to describe the state-of-the-art regarding the wide range of propulsion components on ships and apply the knowledge. They further know how to analyze and optimize the interaction of the components of the propulsion system and how describe complex correlations with the specific technical terms in for German and English. The students are able to name operating behaviour of consumers, describe special requirements on the design of supply networks and to the electric equipment in isolated dirids, wave generation and distribution in isolated grids, wave generation and distribution in isolated grids, wave generation and distribution in isolated grids, wave generation and mane requirements for netw protection, selectivity and operational monitoring. Skills The students are skilled to employ basic and detail knowledge regarding reciprocating machinery, their selection and operation board ships. They are further able to assess, analyse and solve technical and operational problems with propulsion system for ships. Personal Competence Examination of describution in solated grids, wave generation swith propulsion system for ships. Autonomy The students are able to communicate and cooperate in a professional environment in the shipbuilding and component sup industry. <td< td=""><td>Marine Engineering (L1569)</td><td></td><td>Lecture</td><td>2</td><td>2</td></td<>	Marine Engineering (L1569)		Lecture	2	2
Admission Requirements None Recommended Previous Knowledge Educational Objectives After taking part successfully, students have reached the following learning results Professional Competerce Recomplex complex correlations with the specific technical terms in German and English. The students are able to describe the state-of-the-art regarding the wide range of propulsion components on ships and apply the knowledge. They further know how to analyze and optimize the interaction of the components of the propulsion system and how describe complex correlations with the specific technical terms in German and English. The students are able to name operating behaviour of consumers, describe special requirements on the design of supply networks and to the electric equipment in isolated entworks, as e.g. onboard ships, offshore units, factories and emergency power supply systems, expl power generation and distribution in isolated gridy, wave generator systems on ships, and name requirements for netw protection, selectivity and operational monitoring. Skills The students are skilled to employ basic and detail knowledge regarding reciprocating machinery, their selection and operation board ships. They are further able to assess, analyse and solve technical and operational problems with propulsion system for ships. Personal Competence The students are able to communicate and cooperate in a professional environment in the shipbuilding and component sup industry. Autonomy The widespread scope of gained knowledge enables the students to handle situations in their future profession independently a confidently. Workload in Hours <	Marine Engineering (L1570)		Recitation Section (large)	1	1
Recommended Previous Knowledge Educational Objectives After taking part successfully, students have reached the following learning 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 the movie describe complex correlations with the specific technical terms in German and English. The students are able to name operating behaviour of consumers, describe special requirements on the design of supply networks and to the electric equipment in isolated networks, as e.g. onboard ships, difshore units, factories and emergency power supply systems, expl power generation and distribution in isolated grids, wave generator systems on ships, and name requirements for netw protection, selectivity and operational monitoring. Skills The students are skilled to employ basic and detail knowledge regarding reciprocating machinery, their selection and operation board ships. They are further able to assess, analyse and solve technical and operational problems with propulsion and auxili plants and to design propulsion systems. The students have the skills to describe complex correlations and bring them into cont with related disciplines. Students are able to calculate short-circuit currents, switchgear, and design electrical propulsion syste for ships. Personal Competence Social Competence Nocial Competence Social Competence Nocial Competence Nocial to the students sure able to communicate and cooperate in a professional environment in the shipbuilding and component sup industry. Workload In Hours Independent Study Time 96, Study Time in Lecture 84 Correl topints 6 Course achievement None Examination Written exam Social Diminutes plus 20 minutes oral exam s	Module Responsible	Prof. Christopher Friedrich Wirz			
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Social Competence The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supplications in dustry. Autonomy The widespread scope of gained knowledge enables the students to handle situations in their future profession independently a confidently. Workload in Hours Independent Study Time 96, Study Time in Lecture 84 Credit points 6 Course achievement None Examination duration and scale 90 minutes oral exam Assignment for the Following Curricula Energy Systems: Specialisation Energy Systems: Elective Compulsory Following Curricula Energy Systems: Specialisation Marine Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory		plants and to design propulsion systems. The students have the skills to describe complex correlations and bring them into cont with related disciplines. Students are able to calculate short-circuit currents, switchgear, and design electrical propulsion system		ng them into cont	
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Credit points 6 Course achievement None Examination Written exam Examination duration and scale 90 minutes plus 20 minutes oral exam Assignment for the Energy Systems: Specialisation Energy Systems: Elective Compulsory Following Curricula Energy Systems: Specialisation Marine Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory	Autonomy		es the students to handle situations in their	r future professio	n independently a
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 Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory	Workload in Hours	Independent Study Time 96, Study Time in Lecture	e 84		
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	Credit points	6			
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	Course achievement	None			
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	Examination	Written exam			
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Following Curricula Energy Systems: Specialisation Marine Engineering: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory	Assignment for the	Energy Systems: Specialisation Energy Systems: F	lective Compulsory		
Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory	•				
	i siloning curricula	Liergy Systems, Specialisation Marine Engineering	g. companyony		
	-	Theoretical Mechanical Engineering, Engineering	Energy Systems: Elective Compulsors		

ourse L1531: Electrical Inst	allation on Ships
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	 performance in service of electrical consumers. 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. power generation and distribution in isolated networks, shaft generators for ships calculation of short circuits and behaviour of switching devices protective devices, selectivity monitoring electrical Propulsion plants for ships
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 Inst	ourse L1532: Electrical Installation on Ships	
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	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	

ourse 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 Engine	ourse L1570: Marine Engineering	
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	1	
Workload in Hours	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	

Courses				
Title		Тур	Hrs/wk	СР
Aircraft Cabin Systems (L1545)		Lecture	3	4
Aircraft Cabin Systems (L1546)		Recitation Section (large)	1	2
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge	Mathematics			
	Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Control Systems			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	Students are able to:			
	 describe cabin operations, equipment in th 	e cabin and cabin Systems		
	 explain the functional and non-functional re 	equirements for cabin Systems		
	 elucidate the necessity of cabin operating s 	systems and emergency Systems		
	 assess the challenges human factors integr 	ation in a cabin environment		
Skills	Students are able to:			
	 design a cabin layout for a given business i 	nodel of an Airline		
	 design cabin systems for safe operations 			
	 design emergency systems for safe man-m 	achine interaction		
	 solve comfort needs and entertainment rec 	uirements in the cabin		
Personal Competence				
	Students are able to:			
	 understand existing system solutions and of 	liscuss their ideas with experts		
Autonomv	Students are able to:			
	 Reflect the contents of lectures and expert 	presentations self-dependent		
	Independent Study Time 124, Study Time in	Lecture 56		
Credit points Course achievement				
Examination	Written exam			
Examination duration and	120 Minutes			
scale				
Assignment for the	Electrical Engineering: Specialisation Control	and Power Systems Engineering: Elective Com	pulsory	
Following Curricula	Energy Systems: Specialisation Energy Syste	ms: Elective Compulsory		
	Aircraft Systems Engineering: Core qualificat	ion: Compulsory		
	International Management and Engineering:	Specialisation II. Aviation Systems: Elective Cor	npulsory	
	Product Development, Materials and Product	ion: Specialisation Product Development: Electi	ve Compulsory	
	Product Development, Materials and Product	ion: Specialisation Production: Elective Comput	sory	
	Product Development, Materials and Product	ion: Specialisation Materials: Elective Compulso	ory	
	Theoretical Mechanical Engineering: Speciali	sation Aircraft Systems Engineering: Elective C	ompulsory	
	Theoretical Mechanical Engineering: Technic	al Complementary Course [,] Elective Compulsory	,	

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Course L1545: Aircraft Cabin	Sustame
	Lecture
Hrs/wk	
СР	
	Independent Study Time 78, Study Time in Lecture 42
	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	 Skript zur Vorlesung Jenkinson, L.R., Simpkin, P., Rhodes, D.: Civil Jet Aircraft Design. London: Arnold, 1999 Rossow, CC., Wolf, K., Horst, P. (Hrsg.): Handbuch der Luftfahrzeugtechnik. Carl Hanser Verlag, 2014 Moir, I., Seabridge, A.: Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, Wiley 2008 Davies, M.: The standard handbook for aeronautical and astronautical engineers. McGraw-Hill, 2003 Kompendium der Flugmedizin. Verbesserte und ergänzte Neuauflage, Nachdruck April 2006. Fürstenfeldbruck, 2006 Campbell, F.C.: Manufacturing Technology for Aerospace Structural Materials. Elsevier Ltd., 2006

Course L1546: Aircraft Cabin	ourse L1546: Aircraft Cabin Systems	
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	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	

	e Auxiliaries			
Courses				
Title		Тур	Hrs/wk	СР
Electrical Installation on Ships (L15	31)	Lecture	2	2
Electrical Installation on Ships (L15	32)	Recitation Section (large)	1	1
Auxiliary Systems on Board of Ship	s (L1249)	Lecture	2	2
Auxiliary Systems on Board of Ship	s (L1250)	Recitation Section (large)	1	1
Module Responsible	Prof. Christopher Friedrich Wirz			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
Knowledge	The students are able to			
	 name the operating behaviour of considered and the second requirements on the 		aquinment in icel	tod potworks of a
		design of supply networks and to the electrical	equipment in Isola	aleu nelworks, as e
		es and emergency power supply systems,		
		ution in isolated grids, wave generator systems	on snips,	
		ection, selectivity and operational monitoring,		
		rine equipment and apply to product developm		
		uipment components of standard and speciali	zed ships and de	rive requirements
	product development.			
Skills	Students are able to			
	calculate short-circuit currents, switchgear	r,		
	 design electrical propulsion systems for sh 	ips		
	design additional machinery components,	as well as		
	 to apply basic principles of hydraulics and 	to develop hydraulic systems.		
Personal Competence				
	The students are able to communicate and	d cooperate in a professional environment in t	he shipbuilding a	nd component sup
	industry.			
Autonomy	The widespread scope of gained knowledge	enables the students to handle situations in th	eir future professi	on independently a
	confidently.			
Workload in Hours	Independent Study Time 96, Study Time in I	_ecture 84		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
•	Naval Architecture and Ocean Engineering:			
Following Curricula	Theoretical Mechanical Engineering: Technic	cal Complementary Course: Elective Compulsory	/	
	Theoretical Mechanical Engineering: Special	isation Maritime Technology: Elective Compulso	rv	

Course L1531: Electrical Inst	allation on Ships
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	WiSe
Content	 performance in service of electrical consumers. 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. power generation and distribution in isolated networks, shaft generators for ships calculation of short circuits and behaviour of switching devices protective devices, selectivity monitoring electrical Propulsion plants for ships
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 Inst	ourse L1532: Electrical Installation on Ships	
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	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
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christopher Friedrich Wirz
Language	DE
Cycle	SoSe
Content	 Vorschriften zur Schiffsausrüstung Ausrüstungsanlagen auf Standard-Schiffen Ausrüstungsanlagen auf Spezial-Schiffen Grundlagen und Systemtechnik der Hydraulik Auslegung und Betrieb von Ausrüstungsanlagen
Literature	 H. Meyer-Peter, F. Bernhardt: Handbuch der Schiffsbetriebstechnik H. Watter: Hydraulik und Pneumatik

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

Courses							
Fitle		Тур	Hrs/wk	СР			
Analysis of Maritime Systems (L006	8)	Lecture	2	2			
Analysis of Maritime Systems (L006	9)	Recitation Section (small)	1	1			
ntroduction to Maritime Technology	y (L0070)	Lecture	2	2			
ntroduction to Maritime Technology	y (L1614)	Recitation Section (small)	1	1			
Module Responsible	Prof. Moustafa Abdel-Maksoud						
Admission Requirements	None						
Recommended Previous	Solid knowledge and competences in	mechanics, fluid dynamics and analysis (see	ries, periodic f	unctions, continui			
Knowledge	differentiability, integration, multiple var conditions and eigenvalue problems).	iables, ordinaray and partial differential equatio	ns, boundary v	alue problems, init			
Educational Objectives	After taking part successfully, students have	ve reached the following learning results					
Professional Competence							
Knowledge	After successful completion of this class, s and the ability to apply and extend the me	students should have an overview about phenomer thods presented.	a and methods	in ocean engineeri			
	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 offsho	ore systems,					
	 Modeling and evaluation of dynamic 	systems,					
	System-oriented thinking, decomposition	sition of complex systems.					
Skills		I transfer existing methods and techniques on nove Ige and future developments will be discussed.	el questions in m	naritime technologi			
Personal Competence							
Social Competence		of up to four students shall strengthen the commu cque of subsequent working days. The collaboration					
Autonomy	The course contents are absorbed in an ex of the learned is expected without tools.	sercise work in a group and individually checked in	a final exam in v	which a self-reflection			
Workload in Hours	Independent Study Time 96, Study Time in	Lecture 84					
Credit points	6						
Course achievement	None						
Examination	Written exam						
Examination duration and	180 min						
acala							
scale							
Assignment for the	Naval Architecture and Ocean Engineering	: Core qualification: Compulsory nical Complementary Course: Elective Compulsory					

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

Course L0069: Analysis of Ma	ourse L0069: Analysis of Maritime Systems				
Тур	Recitation Section (small)				
Hrs/wk	1				
CP	1				
Workload in Hours	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: Introduction t	o Maritime Technology
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Walter Kuehnlein, Dr. Sven Hoog
Language	DE
Cycle	WiSe
Content	1. Introduction
	Ocean Engineering and Marine Research
	The potentials of the seas
	Industries and occupational structures
	2. Coastal and offshore Environmental Conditions
	 Physical and chemical properties of sea water and sea ice
	Flows, waves, wind, ice
	• Biosphere
	3. Response behavior of Technical Structures
	4. Maritime Systems and Technologies
	General Design and Installation of Offshore-Structures
	Geophysical and Geotechnical Aspects
	Fixed and Floating Platforms
	Mooring Systems, Risers, Pipelines
	Energy conversion: Wind, Waves, Tides
Literature	Chakrabarti, S., Handbook of Offshore Engineering, vol. I/II, Elsevier 2005.
	 Gerwick, B.C., Construction of Marine and Offshore Structures, CRC-Press 1999.
	Wagner, P., Meerestechnik, Ernst&Sohn 1990.
	Clauss, G., Meerestechnische Konstruktionen, Springer 1988.
	Knauss, J.A., Introduction to Physical Oceanography, Waveland 2005.
	Wright, J. et al., Waves, Tides and Shallow-Water Processes, Butterworth 2006.
	 Faltinsen, O.M., Sea Loads on Ships and Offshore Structures, Cambridge 1999.

Course L1614: Introduction t	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: Ship	/ibration			
Courses				
Title		Тур	Hrs/wk	СР
Ship Vibration (L1528)		Lecture	2	3
Ship Vibration (L1529)		Recitation Section (small)	2	3
Module Responsible	Dr. Rüdiger Ulrich Franz von Bock und Polach	1		
Admission Requirements	None			
Recommended Previous	Mechanis I - III			
Knowledge	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		ria for vibrations on ships; they can explain th al components and the entire hull girder; they ds for their determination		
Skills		the calculation of natural frequencies and ex ney can model structures for the vibration ana		esulting vibrations
Personal Competence				
Social Competence	The students are able to communicate and industry.	cooperate in a professional environment in t	he shipbuilding an	nd component supp
Autonomy	Students are able to detect vibration-prone and to assess the results	components on ships, to model the structure	, to select suitable	calculation metho
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	3 hours			
scale				
Assignment for the	Energy Systems: Specialisation Marine Engin	eering: Elective Compulsory		
Following Curricula	Naval Architecture and Ocean Engineering: C	Core qualification: Compulsory		
	Ship and Offshore Technology: Core qualification	tion: Compulsory		
	Theoretical Mechanical Engineering: Specialis	sation Maritime Technology: Elective Compulse	ory	
	Theoretical Mechanical Engineering: Technica	al Complementary Course: Elective Compulsor	y	

Course L1528: Ship Vibration	n
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach
Language	EN
Cycle	WiSe
Content	1. Introduction; assessment of vibrations
	2. Basic equations
	3. Beams with discrete / distributed masses
	4. Complex beam systems
	5. Vibration of plates and Grillages
	6. Deformation method / practical hints / measurements
	7. Hydrodynamic masses
	8. Spectral method
	9. Hydrodynamic masses acc. to Lewis
	10. Damping
	11. Shaft systems
	12. Propeller excitation
	13. Engines
Literature	Ciphe Verlagungeshrint
Literature	Siehe Vorlesungsskript

Course L1529: Ship Vibration	1
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Rüdiger Ulrich Franz von Bock und Polach
Language	EN
Cycle	WiSe
Content	1. Introduction; assessment of vibrations
	2. Basic equations
	3. Beams with discrete / distributed masses
	4. Complex beam systems
	5. Vibration of plates and Grillages
	6. Deformation method / practical hints / measurements
	7. Hydrodynamic masses
	8. Spectral method
	9. Hydrodynamic masses acc. to Lewis
	10. Damping
	11. Shaft systems
	12. Propeller excitation
	13. Engines
Literature	Siehe Vorlesungsskript

Courses							
Title					Тур	Hrs/wk	СР
Industrial Process Automation (LO3					Lecture	2 nall) 2	3
Industrial Process Automation (L03	-				Recitation Section (sm	Idll) Z	3
Module Responsible		der Schl	laeter				
Admission Requirements	1						
Recommended Previous				100S			
Knowledge	principles of		nms and data sti	ructuroc			
	programmin	-		uctures			
	programmin	ig skills					
Educational Objectives	After taking	part suc	ccessfully, stude	nts have reached th	e following learning results		
Professional Competence							
Knowledge	The student	s can ev	aluate and asse	ss discrete event s	stems. They can evaluate pro	perties of processes a	nd explain methods
	process ana	lysis. Th	e students can	compare methods fo	r process modelling and selec	t an appropriate meth	od for actual proble
	They can d	iscuss s	cheduling meth	ods in the context	of actual problems and give	e a detailed explanati	on of advantages
	disadvantag	jes of di	ifferent progran	nming methods. Th	e students can relate proces	s automation to meth	ods from robotics
	sensor syste	ems as w	vell as to recent	topics like 'cyberph'	sical systems' and 'industry 4	.0'.	
Skills			•		and evaluate them according	gly. This involves takin	g into account opti
	scheduling,	understa	anding algorithn	nic complexity, and	implementation using PLCs.		
Personal Competence							
Social Competence		s work ir	n teams to solve	problems			
Social competence	The student	5 WORK II		problems.			
Δυτοροφγ	The student	s can ref	flect their knowl	edge and document	the results of their work.		
Autonomy	The student	5 currer		cuge and document	the results of their work.		
Workload in Hours	Independen	t Study T	Time 124. Study	Time in Lecture 56			
Credit points							
Course achievement		Bonus	Form	Desc	iption		
course demovement		10 %	Excercises				
Examination	Written exa	m					
Examination duration and	90 minutes						
scale							
Assignment for the	Bioprocess F	Engineer	ring: Specialisati	on A - General Biop	ocess Engineering: Elective C	ompulsory	
Following Curricula	Chemical an	nd Biopro	ocess Engineerir	ig: Specialisation Ch	emical Process Engineering: E	lective Compulsory	
	Chemical an	nd Biopro	ocess Engineerir	ng: Specialisation Ge	neral Process Engineering: Ele	ective Compulsory	
	Computer S	cience: S	Specialisation II:	Intelligence Engine	ering: Elective Compulsory		
	Electrical En	ngineerin	ng: Specialisatio	n Control and Power	Systems Engineering: Elective	e Compulsory	
	Aircraft Syst	ems Enç	gineering: Core	qualification: Electiv	e Compulsory		
	Aircraft Syst	tems Eng	gineering: Speci	alisation Cabin Syst	ems: Elective Compulsory		
	Internationa	ıl Manago	ement and Engi	neering: Specialisat	on II. Mechatronics: Elective C	Compulsory	
	Internationa	ıl Manag	ement and Engi	neering: Specialisat	on II. Product Development ar	nd Production: Elective	Compulsory
	Mechanical	Engineer	ring and Manage	ement: Specialisatio	n Mechatronics: Elective Comp	oulsory	
		•	•	-	botics: Elective Compulsory		
	1	Machani	ical Engineering	Technical Compler	entary Course: Elective Comp	oulsory	
	Theoretical	Mechani	ical Engineering	Specialisation Robo	tics and Computer Science: E		
	Theoretical Process Eng	Mechani Jineering	ical Engineering 9: Specialisation	Specialisation Robo Chemical Process En	tics and Computer Science: E ngineering: Elective Compulso : Elective Compulsory		

Course L0344: Industrial Pro	cess Automation
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	- foundations of problem solving and system modeling, discrete event systems
	- properties of processes, modeling using automata and Petri-nets
	- design considerations for processes (mutex, deadlock avoidance, liveness)
	- optimal scheduling for processes
	- optimal decisions when planning manufacturing systems, decisions under uncertainty
	- software design and software architectures for automation, PLCs
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 Pro	ourse L0345: Industrial Process Automation				
Тур	Recitation Section (small)				
Hrs/wk	2				
CP	3				
Workload in Hours	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 M0716: Hiera	rchical Algorithms			
Courses				
Title		Тур	Hrs/wk	СР
Hierarchical Algorithms (L0585)		Lecture	2	3
Hierarchical Algorithms (L0586)		Recitation Section (small)	2	3
Module Responsible	Prof. Sabine Le Borne			
Admission Requirements	None			
Recommended Previous Knowledge	 Mathematics I, II, III for Engineering students (german or english) or Analysis & Linear Algebra I + II as well as Analysis III for 			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	Students are able to			
	 name representatives of hierarchical algorithm 	ns and list their characteristics		
	 explain construction techniques for hierarchical 			
	 discuss aspects regarding the efficient implem 			
<i></i>				
Skills	Students are able to			
	 implement the hierarchical algorithms discuss 	ed in the lecture,		
	 analyse the storage and computational compl 	exities of the algorithms,		
	 adapt algorithms to problem settings of variou 	is applications and thus develop proble	m adapted variants	5.
Personal Competence				
	Students are able to			
	 work together in heterogeneously composed to explain theoretical foundations and support ea 			
		actioner with practical aspects regardi	ig the implementa	
Autonomy	Students are capable			
	 to assess whether the supporting theoretical a 	and practical excercises are better solve	d individually or in	a team.
	 to work on complex problems over an extended 			,
	 to assess their individual progess and, if necessity 			
	Independent Study Time 124, Study Time in Lecture	50		
Credit points Course achievement				
Examination				
Examination duration and scale	20 mm			
Assignment for the	Computer Science: Specialisation III. Mathematics: E	ective Compulson		
•	Technomathematics: Specialisation II. Mathematics: E			
. eening carricula	Theoretical Mechanical Engineering: Technical Comp			
	Theoretical Mechanical Engineering: Specialisation S	, , ,		
Course L0585: Hierarchical A	lgorithms			
Тур	Lecture			
Hrs/wk	2			

Тур	Lecture	
Hrs/wk		
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	 Low rank matrices Separable expansions Hierarchical matrix partitions Hierarchical matrices Formatted matrix operations Applications Additional topics (e.g. H2 matrices, matrix functions, tensor products) 	
Literature	W. Hackbusch: Hierarchische Matrizen: Algorithmen und Analysis	

Course L0586: Hierarchical A	ourse 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		

Courses				
Courses				
Title	2001)	Тур	Hrs/wk	CP
Mathematical Image Processing (L Mathematical Image Processing (L		Lecture Recitation Section (small)	3 1	4
Module Responsible			1	L
Admission Requirements				
Recommended Previous	None			
Kecommended Previous Knowledge	Analysis: partial derivatives, gradient,	directional derivative		
Kilowieuge	• Linear Algebra: eigenvalues, least squ	ares solution of a linear system		
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence	After taking part successionly, students have	reached the following learning results		
	Students are able to			
Knowledge				
	characterize and compare diffusion eq	quations		
	 explain elementary methods of image 	processing		
	 explain methods of image segmentat 			
	 sketch and interrelate basic concepts 	of functional analysis		
Skills	Students are able to			
	• implement and apply elementary met	hade of image processing		
	 implement and apply elementary met explain and apply modern methods or 			
	• explain and apply modern methods of	image processing		
Personal Competence				
Social Competence	Students are able to work together in I	neterogeneously composed teams (i.e., teams	s from different s	study programs a
	background knowledge) and to explain theo	etical foundations.		
Autonomy				
hatehenny	Students are capable of checking their understanding of complex concepts on their own. They can specify open question			
	precisely and know where to get help in solving them.			
		persistence to be able to work for longer period	ods in a goal-orien	ted manner on h
	problems.			
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Bioprocess Engineering: Specialisation A - G	eneral Bioprocess Engineering: Elective Compul	sory	
Following Curricula	Computer Science: Specialisation III. Mathem	natics: Elective Compulsory		
	Computational Science and Engineering: Spe	cialisation III. Mathematics: Elective Compulsor	гy	
	Interdisciplinary Mathematics: Specialisation	Computational Methods in Biomedical Imaging	: Compulsory	
	Mechatronics: Technical Complementary Co			
	Mechatronics: Specialisation System Design			
	Mechatronics: Specialisation Intelligent Systemeters			
	Technomathematics: Specialisation I. Mathe			
		al Complementary Course: Elective Compulsory		
		sation Robotics and Computer Science: Elective	e Compulsory	
	Process Engineering: Specialisation Process	Engineering: Elective Compulsory		

Course L0991: Mathematical	Image Processing
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	WiSe
Content	 basic methods of image processing smoothing filters the diffusion / heat equation variational formulations in image processing edge detection de-convolution inpainting image segmentation image registration
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 M0720: Matri	x Algorithms			
	Algorithing			
Courses				
ītle		Тур	Hrs/wk	СР
Aatrix Algorithms (L0984)		Lecture	2	3
4atrix Algorithms (L0985)		Recitation Section (small)	2	3
Module Responsible				
Admission Requirements				
Recommended Previous	Mathematics I - III			
Knowledge	Numerical Mathematics 1/ Numerics			
	Basic knowledge of the programming la	anguages Matlab and C		
	After taking part successfully, students have	reached the following learning results		
	After taking part successfully, students have i	reached the following learning results		
Professional Competence	Students are able to			
Kilowiedye	Students are able to			
	1. name, state and classify state-of-the-a	rt Krylov subspace methods for the solution of	the core problem	ns of the engineer
	sciences, namely, eigenvalue problems	s, solution of linear systems, and model reduction	on;	
	2. state approaches for the solution of ma	atrix equations (Sylvester, Lyapunov, Riccati).		
Skills	5 Students are capable to			
	 implement and assess basic Krylov su reduction; 	bspace methods for the solution of eigenvalue	problems, linear	systems, and mo
		are with respect to computing time, stability, an	d domain of appli	cability;
	3. adapt the approaches learned to new,			
Personal Competence				
Social Competence	Students can			
	 develop and document joint solutions in 	n small teams:		
		as and transfer them to other areas of applicable	lity:	
	 form a team to develop, build, and adv 		<i>.</i>	
Autonomy	Students are able to			
	 correctly access the time and effort of 	colf defined work		
	 correctly assess the time and effort of a second whether the supporting theoretic 	ical and practical excercises are better solved in	adividually or in a	team:
	 define test problems for testing and ex 		idividually of in a	team,
		necessary, to ask questions and seek help.		
Washingd in Union	Jackson and ant Church Times 124. Church Times in J	ashura EC		
	Independent Study Time 124, Study Time in L	Lecture 30		
Credit points Course achievement				
Examination				
Examination duration and				
Examination duration and scale				
Assignment for the	Technomathematics: Specialisation I. Mathem	natics: Elective Compulsory		
Following Curricula		al Complementary Course: Elective Compulsory		
3	Theoretical Mechanical Engineering: Specialis	. ,		

Course L0984: Matrix 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	 Part A: Krylov Subspace Methods: Basics (derivation, basis, Ritz, OR, MR) Arnoldi-based methods (Arnoldi, GMRes) Lanczos-based methods (Lanczos, CG, BiCG, QMR, SymmLQ, PvL) Sonneveld-based methods (IDR, BiCGStab, TFQMR, IDR(s)) Part B: Matrix Equations: Sylvester Equation Lyapunov Equation Algebraic Riccati Equation 	
Literature	Skript	

Course L0985: Matrix Algorit	rse L0985: Matrix Algorithms		
Тур	Recitation Section (small)		
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			
Literature	Siehe korrespondierende Vorlesung		

Courses				
Title		Тур	Hrs/wk	СР
Numerics of Partial Differential Equations (L1247)		Lecture	2	3
Numerics of Partial Differential Equations (L1247)		Recitation Section (small)	2	3
Module Responsible	Prof. Daniel Ruprecht			
Admission Requirements	None			
Recommended Previous Knowledge	 Mathematik I - IV (for Engineering Students) or Analysis & Linear Algebra I + II for Technomathematicians 			
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Knowledge	 Students can classify partial differential equations according to the three basic types. For each type, students know suitable numerical approaches. Students know the theoretical convergence results for these approaches. 			
Skills	s Students are capable to formulate solution strategies for given problems involving partial differential equations, to comment of theoretical properties concerning convergence and to implement and test these methods in practice.			
Personal Competence				
Social Competence	Students are able to work together in heterogeneously composed teams (i.e., teams from different study programs a background knowledge) and to explain theoretical foundations.			
Autonomy	 Students are capable of checking their understanding of complex concepts on their own. They can specify open questio precisely and know where to get help in solving them. Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on ha problems. 			
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale				
Assignment for the	Computer Science: Specialisation III. Mat	hematics: Elective Compulsory		
Following Curricula	Technomathematics: Specialisation I. Ma	thematics: Elective Compulsory		
	• •	nical Complementary Course: Elective Compulsory		
	i neoretical Mechanical Engineering: Spe	cialisation Simulation Technology: Elective Compuls	огу	

Course L1247: Numerics of F	Partial Differential Equations
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Daniel Ruprecht
Language	DE/EN
Cycle	WiSe
	Elementary Theory and Numerics of PDEs • types of PDEs • well posed problems • finite differences • finite elements • finite volumes • applications
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 P	urse L1248: Numerics of Partial Differential Equations		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Daniel Ruprecht		
Language	DE/EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title		Тур	Hrs/wk	СР
Integrated Product Development II	(L1254)	Lecture	3	3
Integrated Product Development II	(L1255)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Dieter Krause			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of Integrated product development and apply	ving CAE systems		
Educational Objectives	After taking part successfully, students have reached the follo	wing learning results		
Professional Competence				
-	After passing the module students are able to:			
	 explain technical terms of design methodology, 			
	describe essential elements of construction manageme	nt,		
	describe current problems and the current state of rese	arch of integrated product develop	ment.	
Skills	After passing the module students are able to:			
	 select and apply proper construction methods for non- conditions, 	-standardized solutions of problem	s as well as	adapt new bounda
	 solve product development problems with the assistance 	e of a workshop based approach,		
	choose and execute appropriate moderation techniques	5.		
Personal Competence				
Social Competence	After passing the module students are able to:			
	prepare and lead team meetings and moderation proce	sses,		
	 work in teams on complex tasks, 			
	represent problems and solutions and advance ideas.			
Autonomy	After passing the module students are able to:			
	give a structured feedback and accept a critical feedback	sk,		
	• implement the accepted feedback autonomous.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 Minuten			
scale				
Assignment for the	Aircraft Systems Engineering: Specialisation Cabin Systems: E	lective Compulsory		
Following Curricula	Aircraft Systems Engineering: Specialisation Air Transportation			
	Aircraft Systems Engineering: Core qualification: Elective Com			
	International Management and Engineering: Specialisation II. F		on: Elective C	ompulsory
	Mechatronics: Specialisation System Design: Elective Compuls			
	Product Development, Materials and Production: Specialisation		У	
	Product Development, Materials and Production: Specialisation			
	Product Development, Materials and Production: Specialisation Theoretical Mechanical Engineering: Technical Complementary			
	Theoretical Mechanical Engineering: Specialisation Product De		Compulsory	

Course L1254: Integrated Pro	oduct Development II
Тур	Lecture
Hrs/wk	3
CP	
	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	WiSe
Content	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
	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 produc 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	
	 Andreasen, M.M., Design for Assembly, Berlin, Springer 1985. Ashby, M. F.: Materials Selection in Mechanical Design, München, Spektrum 2007. Beckmann, H.: Supply Chain Management, Berlin, Springer 2004. Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater um Trainer, Weinheim, Beltz 2007. Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006. Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000. Simpson, T.W., Siddique, Z., Jiao, R.J.: Product Platform and Product Family Design. Methods and Applications, New York Springer 2013.

Course L1255: Integrated Pr	ourse L1255: Integrated Product Development II		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
CP	3		
Workload in Hours	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				
Fitle		Turn	Hrs/wk	СР
		Typ Lecture	Hrs/wk 2	2
The Digital Enterprise (L0932) Production Planning and Control (L0929)		Lecture	2	2
Production Planning and Control (L0929) Production Planning and Control (L0930)		Recitation Section (small)	1	1
Exercise: The Digital Enterprise (L0933)		Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous	Fundamentals of Production and Quality	Management		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning 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 and present them to others.			
Autonomy				
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 Minuten			
scale				
Assignment for the	International Management and Engineer	ing: Specialisation II. Product Development and Produ	uction: Elective C	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Sp	ecialisation Production and Logistics: Elective Compu	lsory	
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Ir	nplants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation M	ledical Technology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation M	lanagement and Business Administration: Compulsor	У	
	Product Development, Materials and Pro	duction: Specialisation Product Development: Electiv	e Compulsory	
	Product Development, Materials and Pro	duction: Specialisation Production: Compulsory		
	Product Development, Materials and Pro	duction: Specialisation Materials: Elective Compulsor	у	
	Theoretical Mechanical Engineering: Spe	cialisation Product Development and Production: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Tec	hnical Complementary Course: Elective Compulsory		

Course L0932: The Digital Er	iterprise
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	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 Pla	anning and Control
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hermann Lödding
Language	DE
Cycle	WiSe
Content	 Models of Production and Inventory Management Production Programme Planning and Lot Sizing Order and Capacity Scheduling Selected Strategies of PPC Manufacturing Control Production Controlling Supply Chain Management
Literature	 Vorlesungsskript Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008 Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002

Course L0930: Production Pl	ourse L0930: Production Planning and Control		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	1		
Workload in Hours	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	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Axel Friedewald	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	Siehe korrespondierende Vorlesung	
	See interlocking course	

Courses				
Title		Тур	Hrs/wk	СР
Product Planning (L0851)		Lecture	3	3
Product Planning Seminar (L0853)		Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous	Good basic-knowledge of Business Administration			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the	ollowing learning 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 aspects 			
	 Human-Ressource related aspects 			
	 Working-tools, methods and instruments 			
	0			
Borconal Compotonco				
Personal Competence				
Social Competence	Interact within a team			
	Raise awareness for globabl issues			
A 1				
Autonomy	 Gain access to knowledge sources 			
	Interpret complex cases			
	Develop presentation skills			
Werklood in Hours	Independent Study Time 110, Study Time in Lesture 70			
Credit points	Independent Study Time 110, Study Time in Lecture 70			
	Compulsory Bonus Form Descrip	ion		
Course achievement	Yes 20 % Subject theoretical and			
	practical work			
Examination				
	90 minutes			
scale				
Assignment for the	Global Innovation Management: Core gualification: Compu	lsorv		
	International Management and Engineering: Specialisation	,	npulsorv	
, <u>,</u> ,	Mechanical Engineering and Management: Specialisation			
	Product Development, Materials and Production: Specialis		ompulsory	
	Product Development, Materials and Production: Specialis			
	Product Development, Materials and Production: Specialis			
	Theoretical Mechanical Engineering: Specialisation Produc		e Compulsory	
	Theoretical Mechanical Engineering: Technical Compleme			

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Course L0851: Product Plann	ing
Тур	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	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 front-end 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 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.
	passed without the bonus.
Literature	Ulrich, K./Eppinger, S.: Product Design and Development, 2nd. Edition, McGraw-Hill 2010

Course L0853: Product Plann	urse L0853: Product Planning Seminar			
Тур	Project-/problem-based Learning			
Hrs/wk	2			
СР	3			
Workload in Hours	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".			

Courses				
Title		Тур	Hrs/wk	СР
Laser Systems and Process Techno	ologies (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, studen	ts have reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study 7	ime in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	Product Development, Materials and	Production: Specialisation Product Development: E	Elective Compulsory	
Following Curricula	Product Development, Materials and	Production: Specialisation Production: Compulsory	1	
	Product Development, Materials and	Production: Specialisation Materials: Elective Com	pulsory	
	Theoretical Mechanical Engineering: S	Specialisation Product Development and Production	on: Elective Compulsory	,
	Theoretical Mechanical Engineering: 1	echnical Complementary Course: Elective Compu	llsorv	

Course L1612: Laser System	s 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	 Fundamentals of laser technology Laser beam sources: CO2-, Nd:YAG-, Fiber- and Diodelasers Laser system technology: beam forming, beam guidance systems, beam motion and beam control Laser-based manufacturing technologies: generation, marking, cutting, joining, surface treatment Quality assurance and economical aspects of laser material processing Markets and Applications of laser technology Student group exercises
Literature	 Hügel, H., T. Graf: Laser in der Fertigung : Strahlquellen, Systeme, Fertigungsverfahren, 3. Aufl., Vieweg + Teubner Wiesbaden 2014. Eichler, J., Eichler. H. J.: Laser: Bauformen, Strahlführung, Anwendungen, 7. Aufl., Springer-Verlag Berlin Heidelberg 2010. Steen W. M.; Mazumder J.: Laser material processing, 4th Edition, Springer-Verlag London 2010. J.C. Ion: Laser processing of engineering materials: principles, procedure and industrial applications, Elsevier Butterworth-Heinemann 2005. Gebhardt, A.: Understanding additive manufacturing, München [u.a.] Hanser 2011

Course L0876: Methods for A	Analysing Production Processes
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Wolfgang Hintze
Language	DE
Cycle	WiSe
Content	 Modelling and simulation of maching and forming processes Numerical simulation of forces, temperatures, deformation in machining Analysis of vibration problems in maching (chatter, modal analysis,) Knowledge based process planning Design of experiments Machinability of nonmetallic materials Analysis of interaction between maching process and machine tool systems with regard to process stability and quality Simulation of maching processes by virtual reality methods
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)

C				
Courses		T	Une forde	<u></u>
Title Factory Planning (L1445)		Typ Lecture	Hrs/wk 3	СР 3
Production Logistics (L1446)		Lecture	2	3
Module Responsible	Prof. Jochen Kreutzfeldt			
Admission Requirements	None			
Recommended Previous	Bachelor degree in logistics			
Knowledge				
Educational Objectives	After taking part successfully, students have rea	ached the following learning results		
Professional Competence				
Knowledge	The students will acquire the following knowledge	ge:		
	1. The students know the latest trends and deve	elopments in the planning of factories.		
	2. The students can explain basic procedures different conditions.	of factory planning and are able to	deploy these procedure	es while consideri
	3. The students know different methods of facto	ry planning and are able to deal critic	ally with these methods.	
Skills	The students will acquire the following skills:			
	1. The students are able to analyze factories and change of these logistical systems.	nd other material flow systems with i	regard to new developme	ent and the need
	2. The students are able to plan and redesign fa	ctories and other material handling sy	ystems.	
	3. The students are able to develop procedures	for the implementation of new and re	vised material flow syster	ms.
Personal Competence				
Social Competence	The students will acquire the following social ski 1. The students are able to develop plans for th group.		ent of existing material fl	low systems withir
	2. The developed planning proposal from the gro	oup work can be documented and pre	sented together.	
	 The students are able to derive suggestions for constructive criticism themselves. 	or improvement from the feedback or	n the planning proposals a	and can even prov
Autonomy	The students will acquire the following independ	lent competencies:		
	1. The students can plan and re-design material		procedures.	
	 The students can evaluate independently the appropriate methods in a given context. 	e strengths and weaknesses of severa	al techniques for factory	planning and choo
	3. The students are able to carry out autonomou	usly new plans and transformations of	material flow systems.	
Workload in Hours	Independent Study Time 110, Study Time in Lec	ture 70		
Credit points	6			
Course achievement				
Examination				
Examination duration and	120 min			
scale				
-	International Management and Engineering: Spe			ompulsory
Following Curricula	International Management and Engineering: Spe Logistics, Infrastructure and Mobility: Specialisat	•		
	Theoretical Mechanical Engineering: Technical C			
	Theoretical Mechanical Engineering: Specialisati			

ourse L1445: Factory Plann	ing
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
Content	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 (3) Implementation and realization of factory planning
	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.
Literature	 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. 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: Production Lo	gistics
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	DiplIng. Arnd Schirrmann
Language	DE
Cycle	WiSe
Content	 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 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) Logistics-compatible production and process structuring; logistics-compatible product, material flow, information and organizational structures Logistics-oriented production control: situation and development tendencies, logistics and cybernetics, market-oriented production logistics control, monitoring, PPS systems and production control, cybernetic production organization and control, production logistics control systems. Production logistics planning: key performance indicators, developing a production logistics concept, computerized aids to planning production logistics, IPPL functions, economic efficiency of logistics projects 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)
Literature	Pawellek, G.: Produktionslogistik: Planung - Steuerung - Controlling. Carl Hanser Verlag 2007

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Module M0563: Robot	tics				
Courses					
Title		Тур		Hrs/wk	СР
Robotics: Modelling and Control (L0	0168)	Integrated Le	cture	4	4
Robotics: Modelling and Control (L1	305)	Project-/probl	em-based Learning	2	2
Module Responsible	Dr. Martin Gomse				
Admission Requirements	None				
Recommended Previous	Fundamentals of electrical engineering				
Knowledge	Broad knowledge of mechanics				
	broad knowledge of mechanics				
	Fundamentals of control theory				
Educational Objectives	After taking part successfully, students have r	eached the following learning re	sults		
Professional Competence	Arter taking part successions, students have f	eached the following learning re	Suils		
	Students are able to describe fundamental pro	portion of robots and colution a	pproachos for multi	inlo problomo	in robotics
÷				ipie problems	in robotics.
SKIIIS	Students are able to derive and solve equatio		ators.		
	Students can generate trajectories in various	coordinate systems.			
	Students can design linear and partially nonlin	ear controllers for robotic mani	oulators		
	Students can design mear and partially norm		Sulators.		
Personal Competence					
Social Competence	Students are able to work goal-oriented in small mixed groups.				
Autonomy	Students are able to recognize and improve knowledge deficits independently.				
	With instructor assistance, students are able t	o evaluate their own knowledge	level and define a	further course	of study
Workload in Hours	Independent Study Time 96, Study Time in Le	cture 84			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	120 min				
scale					
Assignment for the	Aircraft Systems Engineering: Core qualification	on: Elective Compulsory			
Following Curricula	Aircraft Systems Engineering: Specialisation A	ircraft Systems: Elective Compu	lsory		
	International Management and Engineering: S	pecialisation II. Mechatronics: El	ective Compulsory		
	International Management and Engineering: S		ment and Production	on: Elective Co	ompulsory
	Mechanical Engineering and Management: Co	re qualification: Compulsory			
	Mechatronics: Core qualification: Compulsory				
	Product Development, Materials and Production	•	•	ompulsory	
	Product Development, Materials and Production				
	Product Development, Materials and Productio	•			
	Theoretical Mechanical Engineering: Technica				
	Theoretical Mechanical Engineering: Specialis	ation Robotics and Computer Sci	ience: Elective Com	ipuisory	

Course L0168: Robotics: Modelling and Control		
Тур	Integrated Lecture	
Hrs/wk	4	
СР	4	
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56	
Lecturer	Dr. Martin Gomse	
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: Mod	rse L1305: Robotics: Modelling and Control		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Dr. Martin Gomse		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title		Тур	Hrs/wk	СР
Fluidics (L1256)		Lecture	2	3
Fluidics (L1371)		Project-/problem-based Learning	1	2
Fluidics (L1257)		Recitation Section (large)	1	1
Module Responsible				
Admission Requirements	None			
	Good knowledge of mechanics (stereo statics, elastostatics,	hydrostatics, kinematics and	kinetics), fluid	mechanics, a
Knowledge	engineering design			
Educational Objectives	After taking part successfully, students have reached the following	ng learning results		
Professional Competence				
Knowledge	After passing the module students are able to			
	explain structures and functionalities of hydrostatic, pneur		nents,	
	explain the interaction of hydraulic components in hydrau			
	explain open and closed loop control of hydraulic systems			
	describe functioning and applications of hydrodynamic to	rque converters, brakes and club	ches as well as o	centrifugal pur
	and aggregates in plant technology			
Skills	After passing the module students are able to			
	 analyse and assess hydraulis and phoumatic components 	and systems		
	 analyse and assess hydraulic and pneumatic components design and dimension hydraulic systems for mechanical a 			
	 perform numerical simulations of hydraulic systems based 			
	 select and adapt pump characteristic curves for hydraulic 	•	,	
	 dimension hydrodynamic torque converters and brakes for 			
Personal Competence				
Social Competence	After passing the module students are able to			
	 discuss and present functional context in groups, 			
	organise teamwork autonomously.			
Autonomy	After passing the module students are able to			
	 obtain necessary knowledge for the simulation. 			
	• obtain necessary knowledge for the simulation.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Description			
	Yes None Attestation Simulation hy	drostatischer Systeme		
Examination	Written exam			
Examination duration and	90			
scale	30			
Assignment for the	International Management and Engineering: Specialisation II. Me	chatronics: Elective Compulsory		
Following Curricula	International Management and Engineering: Specialisation II. Me		n: Elective Com	nulsory
i onowing curricula	Product Development, Materials and Production: Specialisation P			parsony
	Product Development, Materials and Production: Specialisation P		3	
	Product Development, Materials and Production: Specialisation P			
	Theoretical Mechanical Engineering: Technical Complementary C	Course: Elective Compulsorv		

Course L1256: Fluidics	
Түр	Lecture
Hrs/wk	
СР	3
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Dieter Krause
Language	DE
Cycle	WiSe
Content	Lecture
	Lecture Hydrostatics • physical fundamentals • hydrostatic machines • valves • components • hydrostatic transmissions • examples from industry Pneumatics • generation of compressed air • pneumatic motors • Examples of use Hydrodynamics • hydrodynamics • hydrodynamics • hydrostatic transmissions • interoperation of motor and transmission Exercise Hydrostatics • reading and design of hydraulic diagrams • dimensioning of hydrodynamic torque converters • 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
Literature	Bücher
	 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, KH.: Dubbel - Taschenbuch für den Maschinenbau, Springer-Verlag, Berlin, aktuelle Auflage
	Skript zur Vorlesung

Course L1371: Fluidics	urse L1371: Fluidics	
Тур	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	ourse L1257: Fluidics	
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	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	

	nical Acoustics II (Room Acoustics	, computational freehous,		
Courses				
Title		Тур	Hrs/wk	СР
Technical Acoustics II (Room Acous	tics, Computational Methods) (L0519)	Lecture	2	3
Technical Acoustics II (Room Acous	tics, Computational Methods) (L0521)	Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Technical Acoustics I (Acoustic Waves, Noise Pro	tection, Psycho Acoustics)		
Knowledge				
	Mechanics I (Statics, Mechanics of Materials) and	I Mechanics II (Hydrostatics, Kinematics, Dyr	iamics)	
	Mathematics I, II, III (in particular differential equ	ations)		
-	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	The students possess an in-depth knowledge in acoustics regarding room acoustics and computational methods and are able t			
	give an overview of the corresponding theoretica	al and methodical basis.		
Skills	The students are capable to handle engine	ering problems in acoustics by theory-b	ased application	of the demand
	computational methods and procedures treated	• • • • •		
Personal Competence				
Social Competence	Students can work in small groups on specific pr	oblems to arrive at joint solutions.		
Autonomy	The students are able to independently solve o	hallenging acoustical problems in the area	s treated within	the module Possi
Autonomy	conflicting issues and limitations can be identifie		s treated within	the module. 1033
		a una the results are entically serutinized.		
Workload in Hours	Independent Study Time 124, Study Time in Lec	ture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	J 20-30 Minuten			
scale				
Assignment for the	Aircraft Systems Engineering: Core qualification:	Elective Compulsory		
Following Curricula	Aircraft Systems Engineering: Specialisation Cab	in Systems: Elective Compulsory		
	Mechatronics: Specialisation System Design: Ele	ctive Compulsory		
	Product Development, Materials and Production:	Core qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical C	omplementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisati			

Course L0519: Technical Acoustics II (Room Acoustics, Computational Methods)		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	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)	
	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 Aco	ourse L0521: Technical Acoustics II (Room Acoustics, Computational Methods)		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	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: Conti	nuum Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1	534)	Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught	, e.g., in the module Mechanics II (forces and	moments, stres	s, linear strain, fre
Knowledge	body principle, linear-elastic constitutive laws, st	rain energy).		
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental conce	pts to calculate the mechanical behavior of m	aterials.	
<i></i>				
SKIIIS	The students can set up balance laws and appli research contexts.	y basics of deformation theory to specific as	pects, both in a	pplied contexts as
	research contexts.			
Personal Competence				
Social Competence	The students are able to develop solutions, to pr	esent them to specialists in written form and	to develop ideas	further.
Autonomy	The students are able to assess their own streng	ths and weaknesses. They can independently	y and on their ov	wn identify and sol
	problems in the area of continuum mechanics ar	d acquire the knowledge required to this end		
Workload in Hours	Independent Study Time 124, Study Time in Lect	cure 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elect	ive Compulsory		
Following Curricula	Mechanical Engineering and Management: Speci	alisation Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Courses	Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial		ompulsory	
	Biomedical Engineering: Specialisation Implants			
	Biomedical Engineering: Specialisation Medical T		-	
	Biomedical Engineering: Specialisation Managem		mpulsory	
	Product Development, Materials and Production:			
	Theoretical Mechanical Engineering: Technical Co			
	Theoretical Mechanical Engineering: Core qualified	cation: Elective Compulsory		

Тур	Lecture
Hrs/wk	
СР	
	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	Fundamentals of tensor calculus
	Transformation invariance
	 Tensor algebra
	Tensor analysis
	Kinematics
	Motion of continuum
	 Deformation of infinitesimal line, area and volume elements
	 Material and spatial description
	 Polar decomposition
	 Spectral decomposition
	Objectivity
	Strain measures
	 Time derivatives
	 Partial / material time derivatives
	 Objective time rates
	 Strain and deformation rates
	• Transport theorems
	Balance equations (global and local form)
	Balance of mass
	• The stress state
	 Surface traction vectors
	 Cauchy's fundamental theorem
	 Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor)
	Balance of linear momentum
	 Balance of angular momentum
	 Balance of energy
	 Balance of entropy
	Clausius-Duhem inequality
	Constitutive laws
	Constitutive assumptions
	• Fluids
	• Elastic solids
	 Hyperelasticity
	 Material symmetry
	Elasto-plastic solids
	Analysis
	 Initial-boundary value problems and their numerical solution
	1
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
	I-S. Liu: Continuum Mechanics, Springer
	weitere siehe in der Literaturliste des Scripts

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

Courses				
Title		Тур	Hrs/wk	СР
Flexible Multibody Systems (L1632 Optimization of dynamical systems		Lecture	2	3 3
Module Responsible		Lecture	L	5
Admission Requirements				
Recommended Previous	None			
Knowledge	Mathematics I, II, III			
	 Mechanics I, II, III, IV 			
	Simulation of dynamical Systems			
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	Students demonstrate basic knowledge	and understanding of modeling, simulation	and analysis of comp	lex rigid and flexi
	multibody systems and methods for optin	nizing dynamic systems after successful com	pletion of the module.	
Skills	Students are able			
JAIIIS				
	+ to think holistically			
	+ to independently, securly and criticall	ly analyze and optimize basic problems of t	the dynamics of rigid a	nd flexible multib
	systems		, ,	
	, to describe dynamics problems mather	matically		
	+ to describe dynamics problems mather	hatically		
	+ to optimize dynamics problems			
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in neterogeneous group	ps and to document the corresponding result	S.	
Autonomy	Students are able to			
	+ assess their knowledge by means of ex	lercises.		
	+ acquaint themselves with the necessar	ry knowledge to solve research oriented tasks	5.	
	Independent Study Time 124, Study Time	e in Lecture 56		
Credit points				
Course achievement				
Examination Examination duration and	Oral exam			
scale				
	Energy Systems: Core qualification: Elect	ive Compulsory		
•	Aircraft Systems Engineering: Core qualif			
J		ion Aircraft Systems: Elective Compulsory		
	Mechatronics: Specialisation System Desi			
	Mechatronics: Specialisation Intelligent S	ystems and Robotics: Elective Compulsory		
		luction: Core qualification: Elective Compulso	ry	
	Theoretical Mechanical Engineering: Core			
	Theoretical Mechanical Engineering: Tech	nnical Complementary Course: Elective Comp	ulsory	

Course L1632: Flexible Multi	body Systems
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried, Dr. Alexander Held
Language	DE
Cycle	WiSe
Content	 Basics of Multibody Systems Basics of Continuum Mechanics Linear finite element modelles and modell reduction Nonlinear finite element Modelles: absolute nodal coordinate formulation Kinematics of an elastic body Kinetics of an elastic body System assembly
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: Optimization	of dynamical systems
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	 Formulation and classification of optimization problems Scalar Optimization Sensitivity Analysis Unconstrained Parameter Optimization Constrained Parameter Optimization Stochastic optimization Stochastic optimization Topology Optimization
Literature	Bestle, D.: Analyse und Optimierung von Mehrkörpersystemen. Springer, Berlin, 1994. Nocedal, J. , Wright , S.J. : Numerical Optimization. New York: Springer, 2006.

Module M0751: Vibra				
Courses				
Title		Тур	Hrs/wk	СР
/ibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusLinear AlgebraEngineering Mechanics			
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 V	bration Theory and develop them fu	rther.	
Skills	Students are able to denote methods of Vibration The	ory and develop them further.		
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research t	asks in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Energy Systems: Core qualification: Elective Compute	ory		
Following Curricula	International Management and Engineering: Specialis	ation II. Mechatronics: Elective Com	pulsory	
	Mechanical Engineering and Management: Specialisa	tion Mechatronics: Elective Compulse	ory	
	Mechatronics: Core qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Orga	ns and Regenerative Medicine: Electi	ive Compulsory	
	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulsor	у	
	Biomedical Engineering: Specialisation Medical Techr	ology and Control Theory: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Management	and Business Administration: Elective	e Compulsory	
	Product Development, Materials and Production: Core	qualification: Compulsory		
	Naval Architecture and Ocean Engineering: Core qua			
	Theoretical Mechanical Engineering: Technical Comp	ementary Course: Elective Compulso	ory	
	Theoretical Mechanical Engineering: Core qualification	n: Elective Compulsory		

Course L0701: Vibration The	ory
Тур	Integrated Lecture
Hrs/wk	4
СР	6
Workload in Hours	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.

C				
Courses				
Title Advanced Topics in Control (L0661		Typ Lecture	Hrs/wk 2	СР 3
Advanced Topics in Control (L0662		Recitation Section (small)	2	3
Module Responsible			_	
Admission Requirements				
	H-infinity optimal control, mixed-sensitivity desig	an linear matrix inequalities		
Knowledge		gri, intear matrix inequalities		
	After taking part successfully, students have rea	ached the following learning results		
Professional Competence				
Knowledge				
	 Students can explain the advantages and 			
	They can explain the representation of no			
	They can explain how stability and perform			
	They can explain how gridding techniques			÷
	They are familiar with polytopic and LF		ome of the basic s	synthesis techniqu
	associated with each of these model struc	ctures		
	 Students can explain how graph theore 	tic concepts are used to represent the	communication to	pology of multipge
	systems	the concepts are used to represent the	communication top	Joiogy of multiage
	 They can explain the convergence proper 	ties of first order consensus protocols		
	 They can explain analysis and synthesis c 		/ing either LTI or LP	V agent models
			5	5
	Students can explain the state space repr	resentation of spatially invariant distribute	d systems that are	discretized accordi
	to an actuator/sensor array			
	• They can explain (in outline) the extens	sion of the bounded real lemma to such	distributed systems	s and the associat
	synthesis conditions for distributed contro	bllers		
Skills				
JKIIIS	 Students are capable of constructing LP 	PV models of nonlinear plants and carry	out a mixed-sensit	civity design of ga
	scheduled controllers; they can do this us	ing polytopic, LFT or general LPV models		
	 They are able to use standard software to 	ools (Matlab robust control toolbox) for the	e tasks	
	Students are able to design distributed f	formation controllers for groups of agents	with either LTI or	LPV dynamics, usi
	Matlab tools provided			
	• Students are able to design distributed as	entrollars for anoticily interconnected syste	ma using the Matla	h MD toolbox
	 Students are able to design distributed co 	ontrollers for spatially interconnected syste	ms, using the Matia	XOGIOOJ-UM GI
Personal Competence				
Social Competence	Students can work in small groups and arrive at	joint results.		
Autonomy	Students are able to find required information in	n sources provided (lecture notes, literature	e, software docume	ntation) and use it
	solve given problems.			
Mendeland States	Independent Charles Times 104, Charles Times 1, 1	turo EG		
Workload in Hours Credit points	Independent Study Time 124, Study Time in Lec	LUIE 30		
Course achievement				
Examination				
Examination duration and				
scale				
	Electrical Engineering: Specialisation Control and	d Power Systems Engineering: Flective Cor	npulsorv	
-	Aircraft Systems Engineering: Specialisation Avid			
	Aircraft Systems Engineering: Specialisation Airc			
	Aircraft Systems Engineering: Core qualification:			
	International Management and Engineering: Spe		ulsory	
	Mechatronics: Specialisation System Design: Ele		-	
	Mechatronics: Specialisation Intelligent Systems			
	Biomedical Engineering: Specialisation Implants			
	Biomedical Engineering: Specialisation Medical T			
	1			
	Biomedical Engineering: Specialisation Managen	nent and Business Administration: Elective	Compulsory	
	Biomedical Engineering: Specialisation Managen Biomedical Engineering: Specialisation Artificial			

Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0661: Advanced Top	pics in Control
Тур	Lecture
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	Linear Parameter-Varying (LPV) Gain Scheduling
	- Linearizing gain scheduling, hidden coupling
	- Jacobian linearization vs. quasi-LPV models
	- Stability and induced L2 norm of LPV systems
	- Synthesis of LPV controllers based on the two-sided projection lemma
	- Simplifications: controller synthesis for polytopic and LFT models
	- Experimental identification of LPV models
	- Controller synthesis based on input/output models
	- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator
	Control of Multi-Agent Systems
	- Communication graphs
	- Spectral properties of the graph Laplacian
	- First and second order consensus protocols
	- Formation control, stability and performance
	- LPV models for agents subject to nonholonomic constraints
	- Application: formation control for a team of quadrotor helicopters
	Linear and Nonlinear Model Predictive Control based on LMIs
Literature	Werner, H., Lecture Notes "Advanced Topics in Control"
	 Selection of relevant research papers made available as pdf documents via StudIP
	l

Course L0662: Advanced Top	pics 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

Courses						
Title		Тур	Hrs/wk	СР		
Nonlinear Structural Analysis (L027	7)	Lecture	3	4 4		
Nonlinear Structural Analysis (L027		Recitation Section (small)	1	2		
Module Responsible	Prof. Alexander Düster					
Admission Requirements						
Recommended Previous	Knowledge of partial differential equation	ns is recommended.				
Knowledge						
Educational Objectives	After taking part successfully, students	have reached the following learning results				
Professional Competence						
Knowledge	Students are able to					
	+ give an overview of the different nonl	inear phenomena in structural mechanics.				
	+ explain the mechanical background or	f nonlinear phenomena in structural mechanics.				
	+ to specify problems of nonlinear strue	ctural analysis, to identify them in a given situation	on and to explain th	eir mathematical a		
	mechanical background.					
Chille						
SKIIIS	Students are able to					
	+ model nonlinear structural problems.	problem a suitable computational procedure				
	+ apply finite element procedures for no	problem a suitable computational procedure.				
	 + critically verify and judge results of nonlinear finite elements. + to transfer their knowledge of nonlinear solution procedures to new problems. 					
		al solution procedures to new problems.				
Personal Competence						
Social Competence	Students are able to					
	+ solve problems in heterogeneous grou	ups and to document the corresponding results.				
	+ share new knowledge with group mer	nbers.				
Autonomy	Students are able to					
Autonomy	+ acquire independently knowledge to s	solve complex problems				
	+ acquire independently knowledge to s	solve complex problems.				
Workload in Hours	Independent Study Time 124, Study Tim	ne in Lecture 56				
Credit points						
Course achievement						
Examination						
Examination duration and						
scale						
Assignment for the	Civil Engineering: Specialisation Structu	ral Engineering: Elective Compulsory				
		ring: Specialisation II. Civil Engineering: Elective C	ompulsory			
	Materials Science: Specialisation Modeli	• •				
	Mechatronics: Specialisation System De					
		duction: Core qualification: Elective Compulsory				
		ng: Core qualification: Elective Compulsory				
	Ship and Offshore Technology: Core qua					
		chnical Complementary Course: Elective Compulse	iry			
		ecialisation Simulation Technology: Elective Comp				

Course L0277: Nonlinear Str	uctural Analysis
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/EN
Cycle	WiSe
Content	1. Introduction
	2. Nonlinear phenomena
	3. Mathematical preliminaries
	4. Basic equations of continuum mechanics
	5. Spatial discretization with finite elements
	6. Solution of nonlinear systems of equations
	7. Solution of elastoplastic problems
	8. Stability problems
	9. Contact problems
Literature	[1] Alexander Düster, Nonlinear Structrual Analysis, Lecture Notes, Technische Universität Hamburg-Harburg, 2014.
	[2] Peter Wriggers, Nonlinear Finite Element Methods, Springer 2008.
	[3] Peter Wriggers, Nichtlineare Finite-Elemente-Methoden, Springer 2001.
	[4] Javier Bonet and Richard D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press,
	2008.

Course L0279: Nonlinear Str	ourse L0279: Nonlinear Structural Analysis	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
Workload in Hours	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: Contr	ol Lab 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 Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	 State space methods 			
	LQG control			
	 H2 and H-infinity optimal control 			
	 uncertain plant models and robust 	control		
	LPV control			
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence	Arter taking part successfully, statents in	ave reached the following learning results		
Knowledge				
Knowledge	Students can explain the difference	e between validation of a control lop in simulation	on and experimental v	validation
Skills	 Students are canable of applying 	g basic system identification tools (Matlab Sys	stem Identification To	olbox) to identify
	dynamic model that can be used f			
		ard software tools (Matlab Control Toolbox) for	the design and imp	lementation of I
	controllers		the design and imp	
		d software tools (Matlab Bebust Control Teolboy) for the mixed consit	tivity docian and t
	 They are capable of using standar implementation of H-infinity optim 	d software tools (Matlab Robust Control Toolbox	.) for the mixed-sensit	livity design and t
			opting a reduct contro	allar
		nodel uncertainty, and of designing and implem		
		d software tools (Matlab Robust Control Toolbox)	for the design and th	le implementation
	LPV gain-scheduled controllers			
Personal Competence				
Social Competence				
,	 Students can work in teams to cor 	duct experiments and document the results		
Autonomy				
Autonomy	 Students can independently carry 	out simulation studies to design and validate co	ntrol loops	
Workload in Hours	Independent Study Time 64, Study Time	in Lecture 56		
Credit points				
Course achievement				
	Written elaboration			
Examination duration and				
scale	-			
	Electrical Engineering: Specialisation Cor	trol and Power Systems Engineering: Elective Co	ompulsory	
-	Mechatronics: Specialisation System Des	, , ,		
i onowing curricula		ystems and Robotics: Elective Compulsory		
		nnical Complementary Course: Elective Compulsory	orv	
		cialisation Robotics and Computer Science: Elective		
	incoretical mechanical Engineering: spe	ciansación nobolics ana computer science: Eleci	Live compulsory	

Course L1093: Control Lab I	
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	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

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Course L1291: Control Lab II	
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	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 L1665: Control Lab II	l
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	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 L1666: Control Lab IV	I
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	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

Courses						
Title				Тур	Hrs/wk	СР
Applied Statistics (L1584)				Lecture	2	3
Applied Statistics (L1586)				Project-/problem-based Learning	2	2
Applied Statistics (L1585)				Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock					
Admission Requirements	None					
Recommended Previous	Basic knowledge of st	tatistical methods				
Knowledge						
Educational Objectives	After taking part succ	essfully, students h	nave reached the following	ng learning results		
Professional Competence						
Knowledge	Students can explain	the statistical meth	nods and the conditions of	of their use.		
Skills	Students are able to u	use the statistics pro	ogram to solve statistics	problems and to interpret and o	depict the res	ults
Personal Competence						
Social Competence	Team Work, joined pr	esentation of result	ts			
Autonomy	To understand and in	torprot the question	n and colvo			
Autonomy		terpret the question	n and solve			
Workload in Hours	Independent Study Ti	me 110, Study Time	e in Lecture 70			
Credit points	6					
Course achievement		Form	Description			
	Yes None	Written elaboratio	on			
Examination	Written exam					
Examination duration and	90 minutes, 28 quest	ions				
scale						
Assignment for the	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory					
Following Curricula			sign: Elective Compulsor			
		-	Systems and Robotics: El	ective Compulsory		
	Biomedical Engineerin	•				
			duction: Core qualificatio			
		5 5	, ,	ourse: Elective Compulsory		
	i neoretical Mechanic	ai Engineering: Spec	cialisation Bio- and Medi	cal Technology: Elective Compu	isory	

Course L1584: Applied Statis	stics
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	
Cycle	WiSe
Content	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 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 Statis	stics
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	2
Workload in Hours	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: Applied Statis	tics
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	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).
	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		Тур	Hrs/wk	СР
Materials Physics (L1624)		Lecture	2	2
Quantum Mechanics and Atomistic		Lecture	2	2
Exercises in Materials Physics and		Recitation Section (small)	2	2
Module Responsible				
Admission Requirements		. for shull the in surface size of the set of the		
Kecommended Previous Knowledge	Advanced mathematics, physics and chemist	ry for students in engineering or natural scien	ces	
-	After taking part successfully, students have	reached the following learning results		
Professional Competence	Arter taking part successfully, students have			
	The students are able to			
	- explain the fundamentals of condensed mai	tter physics		
	- describe the fundamentals of the microscop	ic structure and mechanics, thermodynamics	and optics of mater	ials systems.
	to understand concept and realization of	advanced methods in stemistic modeling as	well as to estimat	a thair natantial an
	limitations.	advanced methods in atomistic modeling as	well as to estimate	e their potential an
Skills	After attending this lecture the students			
	 can perform calculations regarding th 	e thermodynamics, mechanics, electrical and	optical properties	of condensed matte
	systems			
	 are able to transfer their knowledge to 	related technological and scientific fields, e.g	. materials design p	problems.
		tions for specific materials science problems	and are able to fu	rther develop simp
	models.			
Personal Competence		en sistista en el tradevalar islana funthan		
Social Competence	The students are able to present solutions to	specialists and to develop ideas further.		
Autonomy	Students are able to assess their knowldege	continuously on their own by exemplified prac	tice.	
	The students are able to assess their own str	engths and weaknesses and define tasks inde	endently	
			bendentiy.	
Workload in Hours	Independent Study Time 96, Study Time in Lo	ecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Materials Science: Core qualification: Computer	-		
Following Curricula		al Complementary Course: Elective Compulsor	ý	
	Theoretical Mechanical Engineering: Specialis	sation Materials Science: Elective Compulsory		

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

Course L1672: Quantum Mec	hanics and Atomistic Materials Modeling
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Robert Meißner
Language	DE
Cycle	WiSe
Content	- Why atomistic materials modeling
	- Newton's equations of motion and numerical approaches
	- Ergodicity
	- Atomic models
	- Basics of quantum mechanics
	- Atomic & molecular many-electron systems
	- Hartree-Fock and Density-Functional Theory
	- Monte-Carlo Methods
	- Molecular Dynamics Simulations
	- Phase Field Simulations
Literature	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 N	faterials Physics and Modeling
Тур	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Robert Meißner, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	
Literature	- Daan Frenkel & Berend Smit: Understanding Molecular Simulation from Algorithms to Applications
	- Rudolf Gross und Achim Marx: Festkörperphysik
	- Neil Ashcroft and David Mermin: Solid State Physics

Module M1199: Adva	nced Functional Materials			
Courses				
Title		Тур	Hrs/wk	СР
Advanced Functional Materials (L1	525)	Seminar	2	6
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.g	I. Materials Science I/II		
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge		properties of advanced materials along with t tor, modern composite materials (biomaterial		nnology, in particul
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 o 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 present solution	s to specialists and to develop ideas further.		
Autonomy	The students are able to			
	 assess their own strengths and we 	aknesses.		
	 gather new necessary expertise by 	r their own.		
Workload in Hours	Independent Study Time 152, Study Time	e in Lecture 28		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Materials Science: Core qualification: Com	npulsory		
Following Curricula	Mechanical Engineering and Management	t: Specialisation Materials: Elective Compulson	ry	
	Biomedical Engineering: Specialisation Ar	tificial Organs and Regenerative Medicine: Ele	ective Compulsory	
	Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Elective Compuls	sory	
	Biomedical Engineering: Specialisation Me	edical Technology and Control Theory: Electiv	e Compulsory	
	Biomedical Engineering: Specialisation Ma	anagement and Business Administration: Elec	tive Compulsory	
		nical Complementary Course: Elective Compu		
	Theoretical Mechanical Engineering: Spec	ialisation Materials Science: Elective Compuls	sory	

Course L1625: Advanced Fur	nctional Materials	
Тур	Seminar	
Hrs/wk	2	
CP	6	
Workload in Hours	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	1. Porous Solids - Preparation, Characterization and Functionalities	
	2. Fluidics with nanoporous membranes	
	3. Thermoplastic elastomers	
	4. Optimization of polymer properties by nanoparticles	
	5. Fiber composites in automotive	
	5. Modeling of materials based on quantum mechanics	
	7. Biomaterials	
Literature	Aktuelle Publikationen aus der Fachliteratur werden während der Veranstaltung bekanntgegeben.	

Courses				
Title		Тур	Hrs/wk	СР
	nology in cabin electronics and avionics (L1557)	Lecture	2	2
	nology in cabin electronics and avionics (L1558)	Recitation Section (small)	1	1
Model-Based Systems Engineering		Project-/problem-based Learning	3	3
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge	Mathematics			
	Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Control Systems			
	Previous knowledge in:			
	Systems Engineering			
	- Systems Engineering			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				
Knowledge	Students are able to:			
	 describe the structure and operation of computer arc 	nitectures		
	 explain the structure and operation of digital community 	ication Networks		
	$\ensuremath{\cdot}$ explain architectures of cabin electronics, integrated	modular avionics (IMA) and Aircraft Data	Communicatio	on Network (ADCN)
	$\ensuremath{\cdot}$ understand the approach of Model-Based Systems	Engineering (MBSE) in the design of ha	rdware and s	oftware-based cat
	systems			
Skills	Students are able to:			
SKIIIS	understand, operate and maintain a Minicomputer			
	 build up a network communication and communicate 	with other network participants		
	 connect a minicomputer with a cabin management sy 		a AFDX®-Ne	twork
	 model system functions by means of formal language 			
	execute software code on a minicomputer			
Personal Competence				
Social Competence	Students are able to:			
	elaborate partial results and merge with others to for	n a complete solution		
Autonomy	Students are able to:			
	 organize and schedule their practical tasks 			
	Independent Study Time 96, Study Time in Lecture 84			
Credit points				
Course achievement				
	Written exam			
Examination duration and scale	120 minutes			
	Aircraft Systems Engineering: Specialisation Aircraft Sy	stems: Elective Compulsory		
5	Aircraft Systems Engineering: Core qualification: Electiv			
. chowing curricula	International Management and Engineering: Specialisat		sorv	
	Product Development, Materials and Production: Specials		-	
	Product Development, Materials and Production: Specia Product Development, Materials and Production: Specia		511pui301y	
	Product Development, Materials and Production: Specia Product Development, Materials and Production: Specia			
	Theoretical Mechanical Engineering: Technical Compler			
	Theoretical Mechanical Engineering: Specialisation Airc			

ourse L1557: Computer and	communication technology in cabin electronics and avionics
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	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 curren principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronic 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 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 um 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 um Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006

Course L1558: Computer and	d communication technology in cabin electronics and avionics
Тур	Recitation Section (small)
Hrs/wk	1
CP	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 softward 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 currer principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronic 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 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 un Peripherie. Books on Demand; 1. Auflage, 2003
	 Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherhei Books on Demand; 1. Auflage, 2004 Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern un Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006

Тур	Project-/problem-based Learning						
Hrs/wk							
СР							
Workload in Hours	dependent Study Time 48, Study Time in Lecture 42						
Lecturer	Prof. Ralf God						
Language	DE						
Cycle	SoSe						
	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	 Skript zur Vorlesung Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008 Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011 						

Courses								
Title		Тур	Hrs/wk	СР				
Intelligent Autonomous Agents and	Cognitive Robotics (L0341)	Lecture	2	4				
Intelligent Autonomous Agents and	5	Recitation Section (small)	2	2				
Module Responsible	Rainer Marrone							
Admission Requirements								
	Vectors, matrices, Calculus							
Knowledge	vectors, matrices, calculas							
-	After taking part successfully, students have re	ached the following learning results						
Professional Competence								
-	Students can explain the agent abstraction, de	fine intelligence in terms of rational behavior	and give detail	s about agont do				
Knowledge	(goals, utilities, environments). They can descri							
	can be discussed in terms of decision problem							
	world scenarios, students can summarize how	• • •	÷					
	formalism in static and dynamic settings. In a	-						
	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 informatio							
	Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of diffe							
		1 5	igent setting in te	erm of different ty				
	of equilibria, social choice functions, voting protocol, and mechanism design techniques.							
Skills	Students can select an appropriate agent arch	nitecture for concrete agent application scen	arios. For simplifi	ied agent applicat				
	students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesi							
	networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and app							
	different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute th							
	best action or policies for concrete settings. In	multi-agent situations students will apply tec	hniques for findi	ng different equili				
	states,e.g., Nash equilibria. For multi-agent dec	ision making students will apply different voti	ng protocols and	compare and exp				
	the results.							
Personal Competence								
-	Students are able to discuss their solutions to p	problems with others. They communicate in Fr	alish					
social competence	statents are use to discuss their solutions to p	in oblights with others. They communicate in Er	ignon					
Autonomy	Students are able of checking their understand	ing of complex concepts by solving varaints of	f concrete problei	ms				
Workload in Hours	Independent Study Time 124, Study Time in Lev	cture 56						
Credit points								
Course achievement	None							
Examination	Written exam							
Examination duration and	90 minutes							
scale								
Assignment for the	Computer Science: Specialisation II: Intelligence	e Engineering: Elective Compulsory						
•	International Management and Engineering: Sp	• • • • •	e Compulsory					
. eesting carrieula	Mechatronics: Technical Complementary Course: Elective Compulsory							
· · · · · · · · · · · · · · · · · · ·	. ,							
	Mechatronics: Specialisation Intelligent Systems	s and Robotics: Elective Compulsory						
			Compulsory					
<u> </u>	Biomedical Engineering: Specialisation Artificial	Organs and Regenerative Medicine: Elective	Compulsory					
<u> </u>	Biomedical Engineering: Specialisation Artificial Biomedical Engineering: Specialisation Implants	Organs and Regenerative Medicine: Elective s and Endoprostheses: Elective Compulsory						
	Biomedical Engineering: Specialisation Artificial Biomedical Engineering: Specialisation Implants Biomedical Engineering: Specialisation Medical	l Organs and Regenerative Medicine: Elective s and Endoprostheses: Elective Compulsory Technology and Control Theory: Elective Com	pulsory					
	Biomedical Engineering: Specialisation Artificial Biomedical Engineering: Specialisation Implants	l Organs and Regenerative Medicine: Elective s and Endoprostheses: Elective Compulsory Technology and Control Theory: Elective Com ment and Business Administration: Elective Co	pulsory					

Тур	Lecture					
Hrs/wk	2					
CP	4					
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28					
Lecturer	Rainer Marrone					
Language	EN					
Cycle	WiSe					
Content	 Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elemer chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, pro rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, comple independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical- complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be dir perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Ma assumption, transition model, schaman filters, Exact inferences and approximations Decisions withing under uncertainty: Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio Complex decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio Complex decisions and Mapping Planning Game theory (Golden Balls: Split or Share) Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium Social Choice Voting protocols, preferences, paradoxes, Arrow's Theorem, Mechanism Design Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theoo Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected extern mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthw 					
Literature	mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthy Theorem					
	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5 11, 13-17 Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005 					
	 Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambri University Press, 2009 					

Course L0512: Intelligent Au	urse L0512: Intelligent Autonomous Agents and Cognitive Robotics					
Тур	ion Section (small)					
Hrs/wk						
СР	2					
Workload in Hours	ndent Study Time 32, Study Time in Lecture 28					
Lecturer	Marrone					
Language	EN					
Cycle	WiSe					
Content	See interlocking course					
Literature	See interlocking course					

Module M0746: Micro	system	Engine	ering						
Courses									
Title					٦	Гур		Hrs/wk	СР
Microsystem Engineering (L0680)					L	ecture		2	4
Microsystem Engineering (L0682)					F	Project-/problem-ba	sed Learning	2	2
Module Responsible	Dr. rer. nat	t. Thomas k	Kusserow						
Admission Requirements	None								
Recommended Previous	Basic courses in physics, mathematics and electric engineering								
Knowledge									
Educational Objectives	After takin	g part succ	essfully, studen	ts have reached	d the following	learning results			
Professional Competence									
Knowledge	The students know about the most important technologies and materials of MEMS as well as their applications in sensors an actuators.								
Skills	Students are able to analyze and describe the functional behaviour of MEMS components and to evaluate the potential or microsystems.								
Personal Competence									
Social Competence	Students a	re able to s	solve specific pro	oblems alone or	r in a group ar	nd to present the	results accord	dingly.	
	.								
Autonomy		Students are able to acquire particular knowledge using specialized literature and to integrate and associate this knowledge wil other fields.						this knowledge wit	
Workload in Hours	Independe	nt Study Ti	me 124, Study T	ime in Lecture	56				
Credit points	6								
Course achievement	Compulsory	Bonus	Form	D	escription				
	No	10 %	Presentation						
Examination	Written exa	am							
Examination duration and	2h								
scale									
Assignment for the	Electrical E	Engineering	g: Core qualificat	ion: Compulsor	у				
Following Curricula	Internation	nal Manager	ment and Engine	eering: Specialis	sation II. Elect	rical Engineering:	Elective Con	npulsory	
	Internation	nal Managei	ment and Engine	eering: Specialis	sation II. Mech	natronics: Elective	e Compulsory		
		-				onics: Elective Cor	mpulsory		
			lisation System I	÷					
			Microsystems: C						
					-	urse: Elective Cor			
	Theoretica	I Mechanica	al Engineering: S	Specialisation B	io- and Medic	al Technology: Ele	ective Compu	lsory	

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Course L0680: Microsystem	Engineering							
	Lecture							
Hrs/wk								
CP								
Workload in Hours	lependent Study Time 92, Study Time in Lecture 28							
Lecturer	rer. nat. Thomas Kusserow							
Language	N							
Cycle	WiSe							
Content	Object and goal of MEMS							
	Scaling Rules							
	Lithography							
	Film deposition							
	Structuring and etching							
	Energy conversion and force generation							
	Electromagnetic Actuators							
	Reluctance motors							
	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							
Literature	M. Kasper: Mikrosystementwurf, Springer (2000)							
	M. Madou: Fundamentals of Microfabrication, CRC Press (1997)							

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

Courses							
Title Electrical Power Systems II: Operati Electro mobility (L1833)	on and Information Systems of Electrical Power Grids (L1696)	Typ Lecture Lecture	Hrs/wk 3 2	CP 4 2			
Module Responsible	Prof. Martin Kaltschmitt						
Admission Requirements	None						
Recommended Previous Knowledge	Fundamentals of Electrical Engineering						
Educational Objectives	After taking part successfully, students have reached the following learning results						
	Students are able to give an overview of the electric power engineering in the field of renewable energies. They can explain 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. 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	The students can participate in specialized and interdisciplina front of others.	ary discussions, advance i	deas and represent thei	r own work results			
Autonomy	Students can independently tap knowledge of the emphasis of the lectures.						
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70						
Credit points	6						
Course achievement	None						
Examination	Oral exam						
Examination duration and scale	45 min						
-	Energy and Environmental Engineering: Specialisation Energ Renewable Energies: Specialisation Wind Energy Systems: El Renewable Energies: Specialisation Solar Energy Systems: El Theoretical Mechanical Engineering: Technical Complementa	ective Compulsory ective Compulsory		lsory			
	Theoretical Mechanical Engineering: Technical Complementa Theoretical Mechanical Engineering: Specialisation Energy Sy		-				

Тур	Lecture
Hrs/wk	
СР	
	Independent Study Time 78, Study Time in Lecture 42
	Prof. Christian Becker
Language	
Cycle	WiSe
Content	steaedy-state modelling of electric power systems
	 conventional components
	 Flexible AC Transmission Systems (FACTS) and HVDC
	• grid modelling
	• grid operation
	 electric power supply processes
	 grid and power system management
	• grid provision
	grid control systems
	 information and communication systems for power system management
	 IT architectures of bay-, substation and network control level
	 IT integration (energy market / supply shortfall management / asset management)
	 future trends of process control technology
	 smart grids
	 functions and steady-state computations for power system operation and plannung
	 load-flow calculations
	 sensitivity analysis and power flow control
	 power system optimization
	 short-circuit calculation
	 asymmetric failure calculation
	symmetric components
	 calculation of asymmetric failures
	• state estimation
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 mobili	ty
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Klaus Bonhoff
Language	DE
Cycle	WiSe
Content	 Introduction and environment Definition of electric vehicles Excursus: Electric vehicles with fuel cell Market uptake of electric cars Political / Regulatory Framework Historical Review Electric vehicle portfolio / application examples Mild hybrids with 48 volt technology Lithium-ion battery incl. Costs, roadmap, production, raw materials Vehicle Integration Energy consumption of electric cars Battery life Charging Infrastructure Electric road transport Electric public transport Battery Safety
Literature	Vorlesungsunterlagen/ lecture material
Literature	

Courses				
Title		Тур	Hrs/wk	СР
Digital Signal Processing and Digita		Lecture	3	4
Digital Signal Processing and Digita		Recitation Section (large)	2	2
Module Responsible	Prof. Gerhard Bauch			
Admission Requirements	None			
Recommended Previous Knowledge	 Mathematics 1-3 Signals and Systems Fundamentals of signal and system theor Fundamentals of spectral transforms (For 	· ·	form)	
Educational Objectives	After taking part successfully, students have rea	ached the following learning results		
Professional Competence				
-	The students know and understand basic algorithms of digital signal processing. They are familiar with the spectral transforms discrete-time signals and are able to describe and analyse signals and systems in time and image domain. They know ba 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 c perform traditional and parametric methods of spectrum estimation, also taking a limited observation window into account. The students are able to apply methods of digital signal processing to new problems. They can choose and parameterize suital filter structures. In particular, the can design adaptive filters according to the minimum mean squared error (MMSE) criterion a			
Personal Competence	develop an efficient implementation, e.g. bas methods of spectrum estimation and to take the The students can jointly solve specific problems	e effects of a limited observation window int		ts are able to ap
	The students are able to acquire relevant in knowledge during the lecture period by solving	formation from appropriate literature so	-	ontrol their level
Workload in Hours	Independent Study Time 110, Study Time in Leo	ture 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Control an	d Power Systems Engineering: Elective Com	pulsory	
Following Curricula	Computational Science and Engineering: Specia Information and Communication Systems: Spec Mechanical Engineering and Management: Spec Mechatronics: Specialisation Intelligent Systems Microelectronics and Microsystems: Specialisati	ialisation Communication Systems, Focus Si ialisation Mechatronics: Elective Compulsor and Robotics: Elective Compulsory	gnal Processing: Ele	
	Theoretical Mechanical Engineering: Technical (Theoretical Mechanical Engineering: Specialisat			

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

Course L0447: Digital Signal	ourse L0447: Digital Signal Processing and Digital Filters		
Тур	Recitation Section (large)		
Hrs/wk	2		
CP	2		
Workload in Hours	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		

Courses				
Title		Тур	Hrs/wk	СР
Ice Engineering (L1607)		Lecture	2	2
Ice Engineering (L1615)		Recitation Section (small)	1	2
Ship structural design for arctic co		Project-/problem-based Learning	2	2
Module Responsible	Prof. Sören Ehlers			
Admission Requirements	None			
Recommended Previous	none			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following part successfully and the students have reached the following part successfully and the students have reached the students have been successfully and the students have reached the students have been successfully and the students have reached the students have been successfully as the students have be	owing learning 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. Calculatio 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 an			
	defend, the skills and findings will be achieved.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Naval Architecture and Ocean Engineering: Core qualification	n: Elective Compulsory		
Following Curricula	Ship and Offshore Technology: Core qualification: Elective Co	ompulsory		
	Theoretical Mechanical Engineering: Technical Complementa	ary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Maritime	Technology: Elective Compulsory		

Course L1607: Ice Engineerin	ng	
Тур	Lecture	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Dr. Walter Kuehnlein	
Language	EN	
Cycle	WiSe	
Content	1. Ice, Ice Properties, Ice Failure Modes and Challenges and Requirements due to Ice	
	 Introduction, what is/means ice engineering Description of different kinds of ice, main ice properties and different ice failure modes Why is ice so different compared to open water 	
	 Presentation of design challenges and requirements for structures and systems in ice covered waters Ice Load Determination and Ice Model Testing Operating of different empirical equations for simple determination of ice loads 	
	 Overview of different empirical equations for simple determination of ice loads Discussion and interpretation of the different equations and results Introduction to ice model tests 	
	 What are the requirements for ice model tests, what parameters have to be scaled What can be simulated and how to use the results of such ice model tests 	
	 3. Computational Modelling of Ice-Structure Interaction Processes Dynamic fracture and continuum mechanics for modelling ice-structure interaction processes Alternative numerical crack propagation modelling methods. Examples of cohesive element models for real life 	
	 structures. Discussion of contribution of ice properties, hydrodynamics and rubble. 4. Ice Design Philosophies and Perspectives 	
	 What has to be considered when designing structures or systems for ice covered waters What are the main differences compared to open water design Ice Management What are the main ice design philosophies and why is an integrated concept so important for ice 	
	Learning Objectives	
	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	 Proceedings OMAE Proceedings POAC Proceedings ATC 	

Course L1615: Ice Engineerin	ourse L1615: Ice Engineering	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
Workload in Hours	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 structura	ourse L1575: Ship structural design for arctic conditions	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	of. Sören Ehlers, Dr. Rüdiger Ulrich Franz von Bock und Polach	
Language	E/EN	
Cycle	WiSe	
Content	t The structural design under ice loads will be carried out for an individual case	
Literature	FSICR, IACS PC and assorted publications	

Module M0921: Electi	ronic Circuits for Medical Appli	cations		
Courses				
Fitle Electronic Circuits for Medical Appli Electronic Circuits for Medical Appli		Typ Lecture Recitation Section (sm	Hrs/wk 2 nall) 1	CP 3 2
Electronic Circuits for Medical Appli		Practical Course	1	1
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge	Fundamentals of electrical engineering			
	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	 Students can explain the basic functio Students are able to explain the build- Students can exemplify the communic Students can describe the special feat Students can explain the functions of p Students are able to discuss the poten 	up of an action potential and its propaga ation between neurons and electronic de ures of low-noise amplifiers for medical a prostheses, e. g. an artificial hand	tion along an axon evices pplications	
Skills	 Students can calculate the time depe Students can give scenarios for further Students can develop the block diagra Students can define the building block 	improvement of low-noise and low-powe	er signal acquisition.	
Personal Competence Social Competence	 Students are trained to solve probler professional background. Students are able to recognize their sp Students can document their work in whenever it is necessary 	ecific limitations, so that they can ask fo	r assistance to the right	time.
Autonomy	 Students are able to realistically jud necessary. Students can break down their work in Students can handle the complex data Students are able to act in a responsib 	appropriate work packages and schedul structures of bioelectrical experiments v	e their work in a realistic without needing support.	·
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points				
Course achievement	Compulsory Bonus Form Yes None Subject theoretical practical work No None Excercises	Description and		
Examination				
Examination duration and	90 min			
scale Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medic Biomedical Engineering: Specialisation Manage Microelectronics and Microsystems: Specialis	ial Organs and Regenerative Medicine: E nts and Endoprostheses: Elective Compu al Technology and Control Theory: Comp gement and Business Administration: Ele	lsory ulsory ctive Compulsory	
	Theoretical Mechanical Engineering: Technica Theoretical Mechanical Engineering: Specialis	al Complementary Course: Elective Comp	oulsory	

Course L0696: Electronic Cir	cuits for Medical Applications
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
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 Circ	ourse L1056: Electronic Circuits for Medical Applications	
Тур	Recitation Section (small)	
Hrs/wk	1	
CP	2	
Workload in Hours	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: Electronic Circ	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
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 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 (L06	70) Lecture	2	3
Lattice-Boltzmann methods for the	simulation of free surface flows (L2066) Lecture	2	3
Modeling and Simulation of Maritim	ne Systems (L2013) Project-/problem-based Learn	ing 2	3
Offshore Wind Parks (L0072)	Lecture	2	3
Ship Acoustics (L1605)	Lecture	2	3
Ship Dynamics (L0352)	Lecture	2	3
Selected Topics of Experimental an	d Theoretical Fluiddynamics (L0240) Lecture	2	3
Technical Elements and Fluid Mech	anics of Sailing Ships (L0873) Lecture	2	3
Technology of Naval Surface Vesse	ls (L0765) Lecture	2	3
Module Responsible	Prof. Sören Ehlers		
Admission Requirements	None		
Recommended Previous	none		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge			
	 Students are able to find their way through selected special areas within naval archite 	ecture and ocean e	engineering
	 Students are able to explain basic models and procedures in selected special areas. 		
	 Students are able to interrelate scientific and technical knowledge. 		
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 and cooperate in a professional environment in the	ie shipbuilding an	id component supply
	industry.		
Aut	Chudente con chece independently, in which fields they want to depend their line with the set	akilla through the	alaction of courses
Autonomy	Students can chose independently, in which fields they want to deepen their knowledge and	skills through the	election of courses.
Workload in Hours	Depends on choice of courses		
Credit points	6		
Assignment for the	Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory		
Following Curricula	Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsor	Y	
-	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory	-	

Course L1896: Outfitting and	d Operation of Special Purpose Offshore Ships
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
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 ma-jority 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 en-gaged 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 - Jheavy 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: Design of Underwater Vessels	
Тур	
Hrs/wk	
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination 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
	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
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
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
	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
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
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	45 min
scale	
Lecturer	Dr. Alexander Mitzlaff
Language	DE
Cycle	WiSe
Content	 Nonlinear Waves: Stability, pattern formation, solitary states Bottom Boundary layers: wave boundary layers, scour, stability of marine slopes Ice-structure interaction Wave and tidal current energy conversion
Literature	 Chakrabarti, S., Handbook of Offshore Engineering, vol. I&II, Elsevier 2005. Mc Cormick, M.E., Ocean Wave Energy Conversion, Dover 2007. Infeld, E., Rowlands, G., Nonlinear Waves, Solitons and Chaos, Cambridge 2000. Johnson, R.S., A Modern Introduction to the Mathematical Theory of Water Waves, Cambridge 1997. Lykousis, V. et al., Submarine Mass Movements and Their Consequences, Springer 2007. Nielsen, P., Coastal Bottom Boundary Layers and Sediment Transport, World Scientific 2005. Research Articles.

Course L1605: Ship Acoustics	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Dietrich Wittekind
Language	DE
Cycle	SoSe
Content	
Literature	

Course L0352: Ship Dynamic	s
	Lecture
Typ Hrs/wk	
Hrs/wk	
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE
Cycle	SoSe
Content	Maneuverability of ships
	Equations of motion
	Hydrodynamic forces and moments
	Linear equations and their solutions Evill scale trials for evaluating the managementing performance
	 Full-scale trials for evaluating the maneuvering performance Regulations for maneuverability
	Rudder
	Seakeeping
	Representation of harmonic processes
	Motions of a rigid ship in regular waves
	Flow forces on ship cross sections
	Strip method
	Consequences induced by ship motion in regular waves
	Behavior of ships in a stationary sea state
	Long-term distribution of seaway influences
Literature	Abdel-Maksoud, M., Schiffsdynamik, Vorlesungsskript, Institut für Fluiddynamik und Schiffstheorie, Technische Universit
	Hamburg-Harburg, 2014
	Abdel-Maksoud, M., Ship Dynamics, Lecture notes, Institute for Fluid Dynamic and Ship Theory, Hamburg University of
	Technology, 2014
	Bertram, V., Practical Ship Design Hydrodynamics, Butterworth-Heinemann, Linacre House - Jordan Hill, Oxford, Uniter King Lug 2000
	Kingdom, 2000 A Rhattachanwa D. Dunamics of Marina Vahieles, John Wilay S. Sans, Canada 1070
	 Bhattacharyya, R., Dynamics of Marine Vehicles, John Wiley & Sons, Canada,1978 Brix, J. (ed.), Manoeuvring Technical Manual, Seehafen-Verlag, Hamburg, 1993
	 Claus, G., Lehmann, E., Östergaard, C). Offshore Structures, I+II, Springer-Verlag. Berlin Heidelberg, Deutschland, 1992
	 Faltinsen, O. M., Sea Loads on Ships and Offshore Structures, Cambridge University Press, United Kingdom, 1990
	Handbuch der Werften, Deutschland, 1986
	 Jensen, J. J., Load and Global Response of Ships, Elsevier Science, Oxford, United Kingdom, 2001
	Lewis, Edward V. (ed.), Principles of Naval Architecture - Motion in Waves and Controllability, Society of Naval Architects and
	Marine Engineers, Jersey City, NJ, 1989
	Lewandowski, E. M., The Dynamics of Marine Craft: Maneuvering and Seakeeping, World Scientific, USA, 2004
	Lloyd, A., Ship Behaviour in Rough Weather, Gosport, Chichester, Sussex, United Kingdom, 1998

Course L0240: Selected Topi	ourse L0240: Selected Topics of Experimental and Theoretical Fluiddynamics	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
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: Technical Eler	nents and Fluid Mechanics of Sailing Ships
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	
Examination Form	
Examination duration and	30 min
scale	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
	- 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	 Vorlesungs-Manuskript mit Literatur-Liste: Verteilt zur Vorlesung B. Wagner: Fahrtgeschwindigkeitsberechnung für Segelschiffe, IfS-Rep. 132, 1967 B. Wagner: Sailing Ship Research at the Hamburg University, IfS-Script 2249, 1976 A.R. Claughton et al.: Sailing Yacht Design 1&2, University of Southampton, 1998 L. Larsson, R.E. Eliasson: Principles of Yacht Design, Adlard Coles Nautical, London, 2000 K. Hochkirch: Entwicklung einer Messyacht, Diss. TU Berlin, 2000

Course L0765: Technology of	f Naval Surface Vessels
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Martin Schöttelndreyer
Language	DE
Cycle	WiSe
Content	 Operational scenarios, tasks, capabilities, requirements Product and process models, rules and regulations Survivability: threats, signatures, counter measures Design characteristics Energy and propulsion systems Command and combat systems Vulnerability: residual strength, residual functionality
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)

Courses					
Title		Тур	Hrs/wk	СР	
Electrical Power Systems I: Introdue	tion to Electrical Power Systems (L1670)	Lecture	3	4	
Electrical Power Systems I: Introdu	tion to Electrical Power Systems (L1671)	Recitation Section (small)	2	2	
Module Responsible	Prof. Christian Becker				
Admission Requirements	None				
Recommended Previous	Fundamentals of Electrical Engineering				
Knowledge					
Educational Objectives	After taking part successfully, students have reach	hed the following learning results			
Professional Competence					
Knowledge	Students are able to give an overview of conventi evaluate technologies of electric power generatio 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 specialized and in	terdisciplinary discussions, advance ideas	and represent thei	r own work results	
	front of others.				
Autonomy	Students can independently tap knowledge of the	emphasis of the lectures.			
Workload in Hours	Independent Study Time 110, Study Time in Lectu	ire 70			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 - 150 minutes				
scale					
Assignment for the	General Engineering Science (German program, 7	semester): Specialisation Electrical Engin	eering: Elective Co	mpulsory	
Following Curricula	General Engineering Science (German program, 7	semester): Specialisation Green Technolo	gies, Focus Renew	able Energy: Electi	
	Compulsory				
	Data Science: Core qualification: Elective Compuls	sory			
	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				
	Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: Elective Compulsory				
	Computational Science and Engineering: Specialis		ce: Elective Compu	Ilsory	
	Renewable Energies: Core qualification: Compulse Theoretical Mechanical Engineering: Technical Co	•			

Type Lecture Hrs/We 3 C 4 Workload in Hours Independent Study Time 78, Study Time in Lecture 42 Lecture Prof. Christian Becker Content DE Content	Course L1670: Electrical Pow	er Systems I: Introduction to Electrical Power Systems
CP 4 Workload in Hours Independent Study Time 78, Study Time in Lecture 42 Lacturer Prof. Christian Becker Language DE Content • fundamentals and current development trends in electric power engineering • Lasks and history of electric power systems • symmetric three-phase systems • symmetric three-phase systems • fundamentals and modelling of elertic power systems • lines • transformers • synchronous machines • loads and compensation • grid structures and substations • fundamentals of energy conversion • lectro-mechanical energy conversion • electro-mechanics • network modelling • loads ond complexity conversion • steady-state network calculation • network modelling • load flow calculation • network modelling • load flow calculation • network modelling • load flow calculation • (n-1)-criterion • symmetric failure calculations, short-circuit power • control in networks and power stations • grid planning • power economy fundamentals Letterature K. Heuck, K-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013	Тур	Lecture
Workload in Hours Independent Study Time 78, Study Time in Lecture 42 Lecturer Prof. Christian Becker Language DE Cycted Wifse Content • fundamentals and current development trends in electric power engineering • tasks and history of electric power systems • symmetric three-phase systems • fundamentals and modelling of eletric power systems • lines • lines • transformers • induction machines • induction machines • loads and compensation • electro-mechanical energy conversion • electro-mechanical energy conversion • termodynamics • power station technology • renewable energ/ conversion systems • leads and couldition • (n-1)-criterion • symmetric failure calculation • (n-1)-criterion • symmetric failure calculation • grid protection • grid protection • grid protection • grid protection • grid protection • power economy fundamentals • power stations	Hrs/wk	3
Lecturer Prof. Christian Becker Language DE Content fundamentals and current development trends in electric power engineering tasks and history of electric power systems symmetric three-phase systems fundamentals and modelling of eletric power systems indiamentals and modelling of eletric power systems innes transformers synchronous machines loads and compensation grid structures and substations fundamentals of energy conversion electro-mechanical energy conversion electro-mechanical energy conversion electro-mechanical energy conversion electro-mechanical energy conversion steady-state network calculation network modelling load flow calculation network modelling load flow calculation (n-1)-criterion symmetric falure calculations, short-circuit power control in networks and power stations grid protection grid planning power economy fundamentals Literature K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013	СР	4
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Cycle WiSe Content fundamentals and current development trends in electric power engineering tasks and history of electric power systems symmetric three-phase systems fundamentals and modelling of eletric power systems lines transformers synchronous machines induction machines loads and compensation grid structures and substations fundamentals of energy conversion electro-mechanical energy conversion electro-mechanical energy conversion enewable energy conversion steady-state network calculation on-two calculation (n-1)-criterion symmetric failure calculations, short-circuit power control in networks and power stations grid protection grid protection grid protection grid protection grid planning power economy fundamentals Literature K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017 	Lecturer	Prof. Christian Becker
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Literature K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017		• grid planning
A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017		power economy fundamentals
A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017		
	Literature	K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013
P. Floedorff: "Elektrische Eporaioverteilung" Vieweg + Teubper, 9. Auflage, 2008		A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017
A noscom. Elektrische Energieverteilung vieweg + Teublier, 9. Aunage, 2006		R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

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

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Courses					
Title	16.40)		ур	Hrs/wk	СР
Avionics of Safty Critical Systems (L Avionics of Safty Critical Systems (L			ecture ecitation Section (small)	2 1	3 1
Avionics of Safty Critical Systems (L			ractical Course	1	2
Module Responsible					
Admission Requirements					
Recommended Previous					
Knowledge					
	Mathematics				
	Electrical Engineering				
	 Informatics 				
Educational Objectives	After taking part successfully, student	s have reached the following	learning results		
Professional Competence					
Knowledge	Students can:				
	 describe the most important pr 	inciples and components of s	afety-critical avionics		
	 denote processes and standard 	Is of safety-critical software d	evelopment		
	 depict the principles of Integrat 				
	can compare hardware and bus				
	 assess the difficulties of develop 	ping a safety-critical avionics	system correctly		
Chille					
SKIIIS	Students can				
	operate real-time hardware and	d simulations			
	 program A653 applications 				
	 plan avionics architectures up t 	to a certain extend			
	 create test scripts and assess t 	est results			
Personal Competence					
Social Competence	Students can:				
	 jointly develop solutions in inhorities 	omogeneous teams			
	exchange information formally	with other teams			
	 present development results in 	a convenient way			
Autonomy	Students can:				
	 understand the requirements for a second seco	or an avionics system			
	autonomously derive concepts	•	critical avionics		
		-,			
Workload in Hours	Independent Study Time 124, Study T	ime in Lecture 56			
Credit points	6				
course acmevement	Compulsory Bonus Form	Description			
	Yes None Subject theo	pretical and			
	practical work				
	Oral exam				
Examination duration and	30 min				
scale				1	
-	Electrical Engineering: Specialisation			lisory	
-	Aircraft Systems Engineering: Core qu		-		
	Aircraft Systems Engineering: Speciali	-			
	Aircraft Systems Engineering: Speciali Theoretical Mechanical Engineering: T	•			
	Theoretical Mechanical Engineering: 1				

Тир	Lecture
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28
	Dr. Martin Halle
Language	
Cycle	
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
	8. Aircraft Cockpit
	9. Software Development
	10. Model-based Development
	11. Integrated Modular Avionics I
	12. Integrated Modular Avionics II
Literature	Moir, I.; Seabridge, A. & Jukes, M., Civil Avionics Systems Civil Avionics Systems, John Wiley & Sons, Ltd, 2013
	Spitzer, C. R. Spitzer, Digital Avionics Handbook, CRC Press, 2007
	FAA, Advanced Avionics Handbook U.S. Department of Transportation Federal Aviation Administration, 2009
	Moir, I. & Seabridge, A. Aircraft Systems, Wiley, 2008, 3

Course L1641: Avionics of Sa	Course L1641: Avionics of Safty Critical Systems	
Тур	Recitation Section (small)	
Hrs/wk	1	
CP	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 Sa	urse L1652: Avionics of Safty Critical Systems	
Тур	Practical Course	
Hrs/wk	1	
СР	2	
Workload in Hours	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	

Module M1161: Turbo	machinery			
Courses				
Fitle		Tun	Hrs/wk	СР
Turbomachines (L1562)		Typ Lecture	3	4
Turbomachines (L1563)		Recitation Section (large)	1	2
Module Responsible	Prof. Markus Schatz			
Admission Requirements	None			
Recommended Previous	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the followir	ng learning results		
Professional Competence				
Knowledge	The students can			
	distinguish the physical phenomena of conversion of energy	21/		
	 understand the different mathematic modelling of turbom 			
	 calculate and evaluate turbomachinery. 	dennery,		
Skills	The students are able to			
	- understand the physics of Turbomachinery,			
	- solve excersises self-consistent.			
Personal Competence				
Social Competence	The students are able to			
	discuss in small groups and develop an approach.			
Autonomy	The students are able to			
	 develop a complex problem self-consistent, 			
	 analyse the results in a critical way, 			
	 have an qualified exchange with other students. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Energy Systems: Specialisation Energy Systems: Elective Compu	lsory		
Following Curricula	Energy Systems: Specialisation Marine Engineering: Elective Com	npulsory		
	Product Development, Materials and Production: Specialisation P	roduct Development: Elective	Compulsory	
	Product Development, Materials and Production: Specialisation P	roduction: Elective Compulso	ry	
	Product Development, Materials and Production: Specialisation M	laterials: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Complementary C	ourse: Elective Compulsory		

Course L1562: Turbomachine	25	
Тур	Lecture	
Hrs/wk		
CP	4	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Markus Schatz	
Language	DE	
Cycle	SoSe	
Content	Topics to be covered will include:	
	 Application cases of turbomachinery Fundamentals of thermodynamics and fluid mechanics Design fundamentals of turbomachinery Introduction to the theory of turbine stage Design and operation of the turbocompressor Design and operation of the steam turbine Design and operation of the gas turbine Physical limits of the turbomachines 	
Literature	 Traupel: Thermische Turbomaschinen, Springer. Berlin, Heidelberg, New York Bräunling: Flugzeuggasturbinen, Springer., Berlin, Heidelberg, New York Seume: Stationäre Gasturbinen, Springer., Berlin, Heidelberg, New York Menny: Strömungsmaschinen, Teubner., Stuttgart 	

Course L1563: Turbomachine	urse L1563: Turbomachines	
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	2	
Workload in Hours	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	

Courses				
Title		Тур	Hrs/wk	СР
Manoeuvrability of Ships (L1597)	(11500)	Lecture Lecture	2	3 3
Shallow Water Ship Hydrodynamics		Lecture	Z	3
Admission Requirements	Prof. Moustafa Abdel-Maksoud None			
Recommended Previous				
Kecommended Previous Knowledge	B.SC. Schinbau			
	After taking part successfully student	s have reached the following learning results		
Professional Competence	states taking pare successiony, studen	share reacted the following fearing results		
-	analysis of manoeuvring behaviour of ships and explaining the Nomoto equation. The students will know the common model is as well as their assets and drawbacks. Furthermore, the students lern the basics of assessment and prognosis of ship manoeuvrabilit. Basics of characteristics of f around ships in shallow water regarding ship propulsion and manoeuvrability will be aquired.			
Skills				
Personal Competence				
Social Competence				
Autonomy				
	Independent Study Time 124, Study T	ime in Lecture 56		
Credit points				
Course achievement				
Examination				
Examination duration and scale	180 min			
	Naval Architecture and Ocean Engine	ering: Core qualification: Elective Compulsory		
-	Ship and Offshore Technology: Core g			
		echnical Complementary Course: Elective Compl	ulsory	
	5 - 5			

Course L1597: Manoeuvrabil	ity of Ships
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE/EN
Cycle	WiSe
Content	 coordinates & degrees of freedom governing equations of motion hydrodynamic forces & moments ruder forces navigation based on linearised eq.of motion(exemplary solutions, yaw stability) manoeuvering test (constraint & unconstraint motion) slender body approximation 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	 Crane, C. L. H., Eda, A. L., Principles of Naval Architecture, Chapter 9, Controllability, SNAME, New York, 1989 Brix, J., Manoeuvring Technical Manual, Seehafen Verlag GmbH, Hamburg 1993 Söding, H., Manövrieren, Vorlesungsmanuskript, Institut für Fluiddynamik und Schiffstheorie, TUHH, Hamburg, 1995

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

Courses					
		Tour	Une fools	CP	
Title Sustainability Management (L0007)		Typ Lecture	Hrs/wk	CP 1	
Hydro Power Use (L0013)		Lecture	1	1	
Wind Turbine Plants (L0011)		Lecture	2	3	
Wind Energy Use - Focus Offshore (L0012)	Lecture	1	1	
Module Responsible	Dr. Isabel Höfer				
Admission Requirements	None				
Recommended Previous	Module: Technical Thermodynamics I,				
Knowledge					
-	Module: Technical Thermodynamics II,				
	Module: Fundamentals of Fluid Mechanics				
Educational Objectives	After taking part successfully, students have	ve reached the following learning results			
Professional Competence					
	By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy u offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic proce 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				
	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 a assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They car compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects.				
Personal Competence					
Social Competence	Students can discuss scientific tasks subje	t-specificly and multidisciplinary within a s	eminar.		
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of t 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					
	2.5 hours written exam + written elaborati	on (incl. presentation) in sustainability ma	nagement		
scale	2.5 Hours whiteh examinar whiteh elaborat	on (men presentation) in sustainability ma	lagement		
Assignment for the	Civil Engineering: Specialisation Structural	Engineering: Elective Compulsory			
Following Curricula	Civil Engineering: Specialisation Geotechni	5 5 1 5			
ronoming curriculu	• • •				
	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory				
	International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory				
	International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory Product Development Materials and Production: Specialisation Product Development: 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: Co		pulcon		
	Theoretical Mechanical Engineering: Techn				
	Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory				
	Water and Environmental Engineering: Specialisation Environ		ipulsory		

Course L0007: Sustainability	Management
Тур	Lecture
Hrs/wk	2
СР	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dr. Anne Rödl
Language	DE
Cycle	SoSe
Content	The lecture "Sustainability Management" gives an insight into the different aspects and dimensions of sustainability. First, essential terms and definitions, significant developments of the last years, and legal framework conditions are explained. The various aspects of sustainability are then presented and discussed in detail. The lecture mainly focuses on concepts for the implementation of the topic sustainability in companies:
	 What is "sustainability"? Why is this concept an important topic for companies? What opportunities and business risks are addressed or are associated with it? How can the often mentioned three pillars of sustainability - economy, ecology, and social- be meaningfully integrated into corporate management despite their sometimes contradictory tendencies, and how a corresponding compromise can be found? What concepts or frameworks exist for the implementation of sustainability management in companies? Which sustainability labels exist for products or companies? What do they have in common, and where do they differ? Furthermore, the lecture is intended to provide insights into the concrete implementation of sustainability aspects into business practice. External lecturers from companies will be invited to report on how sustainability is integrated into their daily processes. In the course of an independently carried out group work, the students will analyze and discuss the implementation of sustainability aspects based on short case studies. By studying and comparing best practice examples, the students will learn about corporate decisions' effects and implications. It should become clear which risks or opportunities are associated if sustainability aspects are taken into account in management decisions.
Literature	Die folgenden Bücher bieten einen Überblick: 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
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Stefan Achleitner
Language	DE
Cycle	SoSe
Content	 Introduction, importance of water power in the national and global context Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems Construction of hydroelectric power plants: description of the individual components and their technical system interaction Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc. Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection Hydropower and the Environment Examples from practice
Literature	 Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006

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

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

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odule M1165: Ship						
ourses						
ïtle		Тур	Hrs/wk	СР		
hip Safety (L1267)		Lecture	2	4		
hip Safety (L1268)		Recitation Section (large)	2	2		
Module Responsible	Prof. Stefan Krüger					
Admission Requirements	None					
Recommended Previous	Ship Design, Hydrostatics, Statistical Process	es				
Knowledge						
Educational Objectives	After taking part successfully, students have	reached the following learning results				
Professional Competence						
Knowledge	application of existing rules as well as the un	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.				
Skills	organizations are introduced, their responses performance based rules is tackled. Foer diffu illustrated . Further, limitations of saftey rule	ial problems such as grain code uding Stockholm agreement	een prescriptive an the rules on the de nown. Concepts of	eign is		
Personal Competence						
	The student learns to take responsibilty for th	he safety of his designn.				
Autonomy	Responsible certification of technical designs					
Workload in Hours	Independent Study Time 124, Study Time in					
Credit points						
Course achievement	None					
Examination	Written exam					
Examination duration and	180 min					
scale						
Assignment for the	Naval Architecture and Ocean Engineering: C	Core qualification: Compulsory				
Following Curricula		al Complementary Course: Elective Compulsory				
		, ,				

Course L1267: Ship Safety					
Тур	Lecture				
Hrs/wk	2				
СР	4				
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28				
Lecturer	Prof. Stefan Krüger				
Language	DE				
Cycle	WiSe				
Content	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				
	formance based rules is tackled. Foer different examples in ship design, the influence of the rules on the deign is				
	strated . 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 stbility fopr cargo vessels				
	- on board stability, inclining experiment and stability booklet				
	- Relevant manoevering information				
Literature	SOLAS, LOAD LINES, CODE ON INTACT STABILITY. Alle IMO, London.				

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Course L1268: Ship Safety	
Тур	Recitation Section (large)
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

ourses					
ītle		Тур	Hrs/wk	СР	
inear and Nonlinear Waves (L1737)	Project-/problem-based Learning	4	6	
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous	Good Knowledge in Mathematics, Mechanics and Dynamics				
Knowledge					
Educational Objectives	After taking part successfully, students have reached the for	bllowing learning 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 results also in groups.				
Autonomy	Students are able to approach given research tasks individually a	and to identify and follow up novel resear	rch tasks by the	emselves.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	2 Hours				
scale					
Assignment for the	Mechatronics: Specialisation System Design: Elective Comp	oulsory			
Following Curricula	Naval Architecture and Ocean Engineering: Core qualification	on: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Maritime				
	Theoretical Mechanical Engineering: Technical Complement	tary Course: Elective Compulsory			

Course L1737: Linear and No	nlinear Waves	
Тур	Project-/problem-based Learning	
Hrs/wk	4	
СР	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	f. Norbert Hoffmann, Dr. Antonio Papangelo	
Language	N	
Cycle	ie	
Content	roduction into the Dynamics of Linear and Nonlinear Waves.	
Literature	3. Witham, Linear and Nonlinear Waves. Wiley 1999.	
	C.C. Mei, Theory and Applications of Ocean Surface Waves. World Scientific 2004.	

Courses					
Title		Тур		Hrs/wk	СР
Bioelectromagnetics: Principles and		Lecture		3	5
Bioelectromagnetics: Principles and		Recitation Sec	tion (small)	2	1
	Prof. Christian Schuster				
Admission Requirements	None				
Recommended Previous	Basic principles of physics				
Knowledge					
Educational Objectives	After taking part successfully, students hav	e reached the following learning res	sults		
Professional Competence					
Knowledge	Students can explain the basic principles, re	elationships, and methods of bioele	ctromagnetics, i.	e. the quantifica	ation and applicati
	of electromagnetic fields in biological tissu				
	them corresponding to wavelength and fr				
	techniques for characterization of electron	• • • • • •	tions . They can	give examples	for therapeutic a
	diagnostic utilization of electromagnetic fiel	as in medical technology.			
C1.!!!-	Students know how to apply various mathe	de to charactorizo the behavior -f -	lectromagnetic f	ielde in hieles:-	alticula la ard
SKIIIS	Students know how to apply various methor do this they can relate to and make use of				
	important effects that these models predi			-	
	frequency, respectively, and they can analy	• ,			
	predictions. They are able to evaluate the e		-	•	•
	appropriate choice.	······			
Personal Competence					
Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively i				
	English (e.g. during small group exercises).				
Autonomy	Students are capable to gather information	· · · ·	•		
	context of the lecture. They are able to ma		-		
	other lectures (e.g. theory of electromagn		ical engineering	/ physics). The	y can communica
	problems and effects in the field of bioelect	romagnetics in English.			
Workload in Hours	Independent Study Time 110, Study Time ir	Lecture 70			
Credit points					
Course achievement	Compulsory Bonus Form	Description			
-	Yes None Presentation				
Examination	Oral exam				
Examination duration and	45 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Microv	vave Engineering Ontics and Elect	romagnetic Com	natibility: Election	ve Compulsory
•	Electrical Engineering: Specialisation Micro		•	pationity. LIECU	ve compaisory
. showing curricula	International Management and Engineering	3, 1, ,		ompulsorv	
	Biomedical Engineering: Specialisation Artif		•		
	Biomedical Engineering: Specialisation Man				
	Biomedical Engineering: Specialisation Med	-			
	Biomedical Engineering: Specialisation Impl			-	
	Theoretical Mechanical Engineering: Specia	lisation Bio- and Medical Technolog	y: Elective Comp	oulsory	
	Theoretical Mechanical Engineering: Techni	cal Complementary Course: Electiv	e Compulsory		

Тур	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	- 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
	- Behavior of electromagnetic fields of low frequency in biological tissue
	- 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
Literature	- 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)
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

ourse L0373: Bioelectromagnetics: Principles and Applications	
Тур	Recitation Section (small)
Hrs/wk	2
СР	1
Workload in Hours	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

Courses				
		-	11	
Title Biomaterials (L0593)		Typ Lecture	Hrs/wk 2	СР 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and su	rgical techniques is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, student	s have reached the following learning results		
Professional Competence				
Knowledge		als of the human body and the materials being u	ised in medical engineer	ing, and their fields
	use.			
Skills	The students can explain the advanta	ges and disadvantages of different kinds of biom	naterials.	
Personal Competence	The students are able to discuss issue	as related to materials being present or being w	ad for rapla coments wit	h student mater a
Social Competence	the teachers.	es related to materials being present or being us	sed for replacements wit	in student mates a
Autonomy	The students are able to acquire infor	mation on their own. They can also judge the inf	ormation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Tim	me in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
-		eering: Specialisation II. Process Engineering and	Biotechnology: Elective	Compulsory
Following Curricula		o and Hybrid Materials: Elective Compulsory		
		n Artificial Organs and Regenerative Medicine: E	lective Compulsory	
	• • •	n Implants and Endoprostheses: Compulsory	Commulation	
	• • •	n Medical Technology and Control Theory: Electiv		
	• • •	n Management and Business Administration: Ele		
	5 5	echnical Complementary Course: Elective Comp Specialisation Bio- and Medical Technology: Elect	,	

Course L0593: Biomaterials		
Тур	Lecture	
Hrs/wk	2	
СР	3	
	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Michael Morlock	
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	
	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.	
Literature	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.	
	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. Berlin, Springer, 1996.	

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Module M1342: Polyn	lers			
Courses				
Title		Тур	Hrs/wk	СР
Structure and Properties of Polyme		Lecture	2	3 3
Processing and design with polyme		Lecture	Z	3
Module Responsible Admission Requirements	None			
Recommended Previous	Basics: chemistry / physics / material scie	nce		
Knowledge				
Educational Objectives	After taking part successfully, students ha	we reached the following learning results		
Professional Competence				
Knowledge	Students can use the knowledge of plastic	s and define the necessary testing and analy	sis.	
	They can explain the complex relationship	os structure-property relationship and		
	the interactions of chemical structure of t	he polymers, including to explain neighboring	contexts (e.g. sustaina	ability, environmen
	protection).			
Skills	Students are capable of			
511115	·			
	 using standardized calculation method evaluate the different materials. 	ds in a given context to mechanical proper	ties (modulus, streng	th) to calculate a
	 selecting appropriate solutions for mech 	nanical recycling problems and sizing example	stiffness, corrosion re	sistance.
Personal Competence				
Social Competence	Students can			
	- arrive at funded work results in heteroge	phius groups and document them		
	-			
	 provide appropriate feedback and handle 	e feedback on their own performance construc	ctively.	
Autonomy	Students are able to			
Autonomy	Students are able to			
	 assess their own strengths and weaknes 	ses.		
	- assess their own state of learning in spe	cific terms and to define further work steps on	this basis.	
	- assess possible consequences of their pr	rofessional activity		
	- assess possible consequences of their pi			
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the	Materials Science: Specialisation Engineer	ing Materials: Elective Compulsory		
•	Biomedical Engineering: Specialisation Im			
	Biomedical Engineering: Specialisation Art	tificial Organs and Regenerative Medicine: Ele	ctive Compulsory	
		nagement and Business Administration: Elect		
	• • •	edical Technology and Control Theory: Elective		
		uction: Specialisation Production: Elective Con uction: Specialisation Materials: Elective Comp		
		uction: Specialisation Materials: Elective Comp uction: Specialisation Product Development: E	,	
		nical Complementary Course: Elective Compu		
	Theoretical Mechanical Engineering: Spec			

Course L0389: Structure and	Properties of Polymers	
	Lecture	
Hrs/wk		
CP		
	Independent Study Time 62, Study Time in Lecture 28	
	Dr. Hans Wittich	
Language	DE	
Cycle		
Content	- Structure and properties of polymers	
	 Structure of macromolecules Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution Morphology amorph, crystalline, blends Properties 	
	- 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	
Workload in Hours	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	rature 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	

Courses					
Title Formulas and Vehicles - Mathemati	cs and Mechanics in Autonomous Driving (L1981)	Typ Project-/problem-based Learning	Hrs/wk 2	CP 6	
Module Responsible	Prof. Robert Seifried				
Admission Requirements	None				
Recommended Previous	Mechanics IV, Applied Dynamics or Robotics				
Knowledge	Numerical Treatment of Ordinary Differential Equations				
	Control Systems Theory and Design				
Educational Objectives	After taking part successfully, students have reached t	ne following learning results			
Professional Competence					
Knowledge	After successful completion of the module students of areas of multibody dynamics and robotics	lemonstrate deeper knowledge and unde	erstanding in	selected applicati	
Skills	Students are able				
	+ to think holistically				
	+ to independently, securly and critically analyze and systems	d optimize basic problems of the dynami	cs of rigid ar	nd flexible multibo	
	+ to describe dynamics problems mathematically				
	+ to implement dynamical problems on hardware				
Personal Competence					
Social Competence	Students are able to				
	+ solve problems in heterogeneous groups and to docu	ment the corresponding results and prese	ent them		
Autonomy	Students are able to				
	+ assess their knowledge by means of exercises and p	ojects.			
	+ acquaint themselves with the necessary knowledge t	o 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	ТВА				
Assignment for the	Mechatronics: Specialisation Intelligent Systems and Ro	botics: Elective Compulsory			
Following Curricula	Mechatronics: Specialisation System Design: Elective C	ompulsory			
	Theoretical Mechanical Engineering: Technical Complex	nentary Course: Elective Compulsory			

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

Module M1249: Medie	cal Imaging				
Courses					
Title		Тур	Hrs/wk	СР	
Medical Imaging (L1694)		Lecture	2	3	
Medical Imaging (L1695)		Recitation Section (small)	2	3	
Module Responsible	Prof. Tobias Knopp				
Admission Requirements	None				
Recommended Previous	Basic knowledge in linear algebra, numerics, and s	signal processing			
Knowledge					
Educational Objectives	After taking part successfully, students have reach	ned the following learning results			
Professional Competence					
Knowledge	After successful completion of the module, students are able to describe reconstruction methods for different tomographic imagin modalities such as computed tomography and magnetic resonance imaging. They know the necessary basics from the fields signal processing and inverse problems and are familiar with both analytical and iterative image reconstruction methods. The students have a deepened knowledge of the imaging operators of computed tomography and magnetic resonance imaging.				
Skills	The students are able to implement reconstruction methods and test them using tomographic measurement data. They can visualize the reconstructed images and evaluate the quality of their data and results. In addition, students can estimate the temporal complexity of imaging algorithms.				
Personal Competence					
Social Competence	Students can work on complex problems both inde	ependently and in teams. They can excha	ange ideas with eac	h other and use the	
	individual strengths to solve the problem.				
Autonomy	Students are able to independently investigate a complex problem and assess which competencies are required to solve it.				
Workload in Hours	Independent Study Time 124, Study Time in Lectu	re 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 min				
scale					
Assignment for the	Computer Science: Specialisation II: Intelligence En	ngineering: Elective Compulsory			
Following Curricula	Electrical Engineering: Specialisation Medical Tech	nology: Elective Compulsory			
	Interdisciplinary Mathematics: Specialisation Comp	outational Methods in Biomedical Imaging	g: Compulsory		
	Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory				
	Theoretical Mechanical Engineering: Specialisation	Bio- and Medical Technology: Elective C	ompulsory		
	Theoretical Mechanical Engineering: Technical Cor	nplementary Course: Elective Compulsor	у		

Course L1694: Medical Imag	ing			
Тур	Lecture			
Hrs/wk	2			
СР				
Workload in Hours	ependent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Tobias Knopp			
Language	DE/EN			
Cycle	WiSe			
Content	 Overview about different imaging methods Signal processing Inverse problems Computed tomography Magnetic resonance imaging Compressed Sensing Magnetic particle imaging 			
Literature	 Bildgebende Verfahren in der Medizin; O. Dössel; Springer, Berlin, 2000 Bildgebende Systeme für die medizinische Diagnostik; H. Morneburg (Hrsg.); Publicis MCD, München, 1995 Introduction to the Mathematics of Medical Imaging; C. L.Epstein; Siam, Philadelphia, 2008 Medical Image Processing, Reconstruction and Restoration; J. Jan; Taylor and Francis, Boca Raton, 2006 Principles of Magnetic Resonance Imaging; ZP. Liang and P. C. Lauterbur; IEEE Press, New York, 1999 			

Module Manual M.Sc. "Theoretical Mechanical Engineering"

Course L1695: Medical Imagi	urse L1695: Medical Imaging			
Тур	itation Section (small)			
Hrs/wk	2			
СР	3			
Workload in Hours	ependent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Tobias Knopp			
Language	DE/EN			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M1294: Bioen	erav					
Module M1294. Bioen	ergy					
Courses						
Title			p	Hrs/wk	СР	
Biofuels Process Technology (L006	1)	Lec	ture	1	1	
Biofuels Process Technology (L006			itation Section (small)	1	1	
World Market for Commodities fron Thermal Biomass Utilization (L1767			ture	1 2	1 2	
Thermal Biomass Utilization (L176)			ture ctical Course	2	2	
	Prof. Martin Kaltschmitt			_	_	
Admission Requirements						
Recommended Previous						
Knowledge						
5	After taking part successfully, students hav	ve reached the following le	earning results			
Professional Competence			y			
	Students are able to reproduce an in-dept	th outline of energy prod	uction from biomass, ae	robic and anaero	bic waste treatmer	
5	processes, the gained products and the trea					
Skills	Is Students can apply the learned theoretical knowledge of biomass-based energy systems to explain relationships for different					
	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.					
4						
Autonomy	Students can independently exploit sources					
	particular task useful knowledge. Furthermore, they can solve computational tasks of biomass-based energy system independently with the assistance of the lecture. Regarding to this they can assess their specific learning level and ca consequently define the further workflow.					
	consequency define the further worknow.					
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84					
Credit points	6					
Course achievement	None					
Examination	Written exam					
Examination duration and	3 hours written exam					
scale						
Assignment for the	Bioprocess Engineering: Specialisation A - G	General Bioprocess Engine	ering: Elective Compuls	ory		
Following Curricula	Bioprocess Engineering: Specialisation C -	Bioeconomic Process En	gineering, Focus Energy	and Bioprocess	Technology: Elective	
	Compulsory					
	Energy and Environmental Engineering: Spe	•••	•	g: Elective Compu	llsory	
	Energy Systems: Specialisation Energy Syst					
	International Management and Engineering		able Energy: Elective Cor	mpulsory		
	Renewable Energies: Core qualification: Cor					
	Theoretical Mechanical Engineering: Techni					
	Process Engineering: Specialisation Environ	nmental Process Engineeri	ng: Elective Compulsory			

ourse L0061: Biofuels Proce	ess Technology				
Тур	Lecture				
Hrs/wk	1				
CP	1				
Workload in Hours	ndependent Study Time 16, Study Time in Lecture 14				
Lecturer	of. Oliver Lüdtke				
Language	DE				
Cycle	WiSe				
Content	General introduction				
	What are biofuels?				
	Markets & trends				
	Legal framework				
	Greenhouse gas savings				
	Generations of biofuels				
	 first-generation bioethanol 				
	■ raw materials				
	 fermentation distillation 				
	◦ biobutanol / ETBE				
	 second-generation bioethanol 				
	 bioethanol from straw 				
	 first-generation biodiesel 				
	 raw materials 				
	Production Process				
	Biodiesel & Natural Resources				
	◇ HVO / HEFA				
	 second-generation biodiesel 				
	 Biodiesel from Algae 				
	Biogas as fuel				
	 the first biogas generation 				
	 raw materials 				
	 fermentation 				
	 purification to biomethane 				
	 Biogas second generation and gasification processes 				
	- Methanol / DME from wood and Tall oil $\ensuremath{\mathbb{C}}$				
Literature	Skriptum zur Vorlesung				
	Drapcho, Nhuan, Walker; Biofuels Engineering Process Technology				
	Harwardt; Systematic design of separations for processing of biorenewables				
	 Kaltschmitt; Hartmann; Energie aus Biomasse: Grundlagen, Techniken und Verfahren 				
	 Mousdale; Biofuels - Biotechnology, Chemistry and Sustainable Development 				
	VDI Wärmeatlas				

Course L0062: Biofuels Proce	ass Technology
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Oliver Lüdtke
Language	DE
Cycle	WiSe
Content	 Life Cycle Assessment Good example for the evaluation of CO2 savings potential by alternative fuels - Choice of system boundaries and databases Bioethanol production 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 Biodiesel production Procedural options for solid / liquid separation, including basic equations for estimating power, energy demand, selectivity and throughput Biomethane production Chemical reactions that are relevant in the production of biofuels, including equilibria, activation energies, shift reactions
Literature	Skriptum zur Vorlesung

Course L1769: World Market	for Commodities from Agriculture and Forestry			
Тур	Lecture			
Hrs/wk	1			
CP	1			
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14			
Lecturer	Prof. Michael Köhl, Bernhard Chilla			
Language	DE			
Cycle	WiSe			
Content	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 by-product (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			
	ears 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.			
	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			

	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecture	Prof. Martin Kaltschmitt
Language	DE
Cycle	WiSe
Content	Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmenti basics of all options to provide energy from biomass from a German and international point of view. Additionally different syster approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and econom development potentials, and the current and expected future use within the energy system are presented.
	 Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on th content of the course Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying Thermo-chemical conversion of solid biofuels Basics of thermo-chemical conversion 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 Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer ga for the provision of heat, electricity and/or fuels 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 raw material Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil productior 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) Bio-chemical conversion of biomass
	 Basics of bio-chemical conversion Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic wast fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fue use of the stillage

Course L2386: Thermal Biom	ass Utilization
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	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	 Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science & Business Media, 2016ISBN 978-3-662-47437-2 Versuchsskript

Courses						
Title		Тур	Hrs/wk	СР		
Fatigue Strength of Ships and Offshore Structures (L1521)		Lecture	2	3		
Fatigue Strength of Ships and Offs	nore Structures (L1522)	Recitation Section (small)	2	3		
Module Responsible	Prof. Sören Ehlers					
Admission Requirements	None					
Recommended Previous	Structural analysis of ships and/or offsho	re structures and fundamental knowledge in mech	anics and mechani	ics of materials		
Knowledge						
Educational Objectives	After taking part successfully, students h	nave reached the following learning results				
Professional Competence						
Knowledge	Students are able to					
	 describe fatigue loads and stresses, as well as describe structural behaviour under cyclic loads. 					
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 su industry.					
	industry.					
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently a					
	confidently.					
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56				
Credit points						
Course achievement						
Examination						
Examination duration and						
scale						
	Naval Architecture and Ocean Engineering	ng: Core qualification: Elective Compulsory				
-	Ship and Offshore Technology: Core qua					
-		hnical Complementary Course: Elective Compulsor	/			
		cialisation Maritime Technology: Elective Compulso				

Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	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 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

Course L1522: Fatigue Stren	ourse L1522: Fatigue Strength of Ships and Offshore Structures	
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	3	
Workload in Hours	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 M1744: Selected Topics of Aeronautical Systems Engineering (Alternative A: 6 LP)

Courses				
Courses				
Title		Тур	Hrs/wk	СР
Advanced Training Course SE-ZERT (L2739)		Project-/problem-based Learning	2	3
Airline Operations (L1310)		Lecture	3	3
Fatigue & Damage Tolerance (L031	10)	Lecture	2	3
Flight Guidance (L0848)		Lecture	2 1	2
Flight Guidance (L0854) Airport Operations (L1276)		Recitation Section (large) Lecture	3	3
Airport Planning (L1275)		Lecture	2	2
Airport Planning (L1469)		Recitation Section (small)	1	1
Lightweight Design Practical Course	e (L1258)	Project-/problem-based Learning	3	3
Aviation Security (L1549)		Lecture	2	2
Aviation Security (L1550)		Recitation Section (small)	1	1
Aviation and Environment (L2376)		Lecture	3	3
Mechanisms, Systems and Process	es of Materials Testing (L0950)	Lecture	2	2
Mission Management (L2374)		Lecture	2	2
Mission Management (L2375)		Recitation Section (small)	1	1
Turbo Jet Engines (L0908)		Lecture	2	3
Structural Mechanics of Fibre Reinf	•	Lecture	2	3
Structural Mechanics of Fibre Reinf	forced Composites (L1515)	Recitation Section (large)	1	1
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Materials Testing (L0949)		Lecture	2	2
Reliability in Engineering Dynamics		Lecture	2	2
Reliability in Engineering Dynamics		Recitation Section (small)	1	2
Reliability of Aircraft Systems (L074	49)	Lecture	2	3
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge				
	Mathematics			
	Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Hydraulics			
	Control Systems			
	After taking part successfully, students have reached th	ne following learning results		
Professional Competence				
Knowledge	 Students are able to find their way through select 	ted special areas within systems enginee	ring air trans	nortation system an
	, ,	ted special areas within systems enginee	ring, an crans	portation system an
	material science			
	Students are able to explain basic models and pr			
	Students are able to interrelate scientific and tec	hnical knowledge.		
Skills	Students are able to apply basic methods in selected an	reas of engineering.		
Personal Competence				
Social Competence				al a al tara a f
Autonomy	Students can chose independently, in which fields they	want to deepen their knowledge and skill	s through the	election of courses.
Workload in Hours	Depends on choice of courses			
Credit points	6			
	Aircraft Systems Engineering: Core qualification: Electiv	e Compulsory		
Assignment for the	i in cruit by stario Engliteering. Core qualification Electric			
Assignment for the Following Curricula			llsory	

Course L2739: Advanced Tra	ining Course SE-ZERT
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	120 min
scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der
	deutschen Übersetzung), ISBN 978-3-9818805-0-2.
	ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System
	Life Cycle Processes).

Course L1310: Airline Operat	tions		
Тур	ecture		
Hrs/wk	3		
СР	3		
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42		
Examination Form	Klausur		
Examination duration and	90 min		
scale			
Lecturer	Prof. Volker Gollnick, Dr. Karl Echtermeyer		
Language	DE		
Cycle	SoSe		
Content	 Introdution and overview Airline business models Interdependencies in flight planning (network management, slot management, netzwork structures, aircraft circulation) Operative flight preparation (weight & balance, payload/range, etc.) fleet policy Aircraft assessment and fleet planning Airline organisation Aircraft maintenance, repair and overhaul 		
Literature	Volker Gollnick, Dieter Schmitt: The Air Transport System, Springer Berlin Heidelberg New York, 2014 Paul Clark: "Buying the Big Jets", Ashgate 2008 Mike Hirst: The Air Transport System, AIAA, 2008		

Course L0310: Fatigue & Dar	nage Tolerance
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	45 min
scale	
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 L0848: Flight Guidan	ce
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	60 min
scale	
	Prof. Volker Gollnick
Language	
Cycle	
Content	Introduction and motivation Flight guidance principles (airspace structures, organization of air navigation services, etc.)
	Cockpit systems and Avionics (cockpit design, cockpit equipment, displays, computers and bus systems)
	Principles of flight measurement techniques (Measurement of position (geometric methods, distance measurement, direction
	measurement) Determination of the aircraft attitude (magnetic field- and inertial sensors) Measurement of speed
	Principles of Navigation
	Radio navigation
	Satellite navigation
	Airspace surveillance (radar systems)
	Commuication systems
	Integrated Navigation and Guidance Systems
Literature	Rudolf Brockhaus, Robert Luckner, Wolfgang Alles: "Flugregelung", Springer Berlin Heidelberg New York, 2011
	Holger Flühr: "Avionik und Flugsicherungssysteme", Springer Berlin Heidelberg New York, 2013
	Volker Gollnick, Dieter Schmitt "Air Transport Systems", Springer Berlin Heidelberg New York, 2016
	R.P.G. Collinson "Introduction to Avionics", Springer Berlin Heidelberg New York 2003

Course L0854: Flight Guidance	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1276: Airport Opera	tions
Тур	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Volker Gollnick, Peter Willems (geb. Bießlich)
Language	DE
Cycle	WiSe
Content	FA-F Flight Operations Flight Operations - Production Infrastructures Operations Planning Master plan Airport capacity Ground
	handling Terminal operations
Literature	Richard de Neufville, Amedeo Odoni: Airport Systems, McGraw Hill, 2003

Course L1275: Airport Plann	ing
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick, Dr. Ulrich Häp
Language	DE
Cycle	WiSe
Content	 Introduction, definitions, overviewg Runway systems Air space strucutres around airports Airfield lightings, marking and information Airfield and terminal configuration
Literature	N. Ashford, Martin Stanton, Clifton Moore: Airport Operations, John Wiley & Sons, 1991 Richard de Neufville, Amedeo Odoni: Airport Systems, Aviation Week Books, MacGraw Hill, 2003

ourse L1469: Airport Planning	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick, Dr. Ulrich Häp
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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

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	90 Minuten
scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
	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 mar 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	 Skript zur Vorlesung Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011 Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

Course L1550: Aviation Security	
Typ Recitation Section (small)	
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	90 Minuten
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	- Skript zur Vorlesung
	- Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011
	- olemana, E.M., Notre B.N. (msg.). Handbuch Luitsicherheit. Universitätsverlag TU bernin, 2011
	- Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008

ourse L2376: Aviation and	znvironment
Тур	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	SoSe
	The lecture provides the necessary basics and methods for understanding the interactions between air traffic and the environme
	both in terms of the effects of weather / climate on flying and with regard to the effects of air traffic on pollutant emissions, noi and climate.
	The following topics are covered:
	Atmospheric physics / chemistry
	 Structure and statics
	 Dynamics (water cycle, formation of weather events, high and low pressure areas, wind, gusts and turbulence) Cloud physics (thermodynamics, contrails)
	 Radiation physics (energy balance, greenhouse effect)
	• Photochemistry (ozone chemistry)
	Impact of weather on flying
	 Atmospheric influences on flight performance
	• Flight planning
	• Disturbances due to weather, e.g. thunderstorms, winter weather (icing), clear air turbulence, visibility
	• Effects of climate change and adaptation
	Effects of air traffic on the environment and climate
	Aviation pollutant emissions Effect of emissions on concentrations in the atmosphere
	Effect of emissions on concentrations in the atmosphere Climate matrice / medicle and background scenarios
	 Climate metrics / models and background scenarios Emissions inventories
	Mitigation measures
	 Technological measures, e.g. climate-optimized aircraft design
	Alternative fuels
	 Operational measures, e.g. climate-optimized flight planning
	 Environmental policy measures, e.g. EU-ETS, CORSIA
	 Potentials and comparison, concept of eco-efficiency
	Local environmental impacts
	 Local air quality (particulate matter, other emissions near the ground)
	 Noise (noise sources, noise metrics, noise impact, measurement, certification, psychoacoustics, noise mitigation)
	• Health effects
	Aspects of sustainability
	 Other aspects, including life cycle emissions, disposal/recycling
	• Relation to global goals, e.g. United Nations goals for sustainable development, Paris climate agreement
Literature	Puijgrok, C.: Elements of Aircraft Pollution, Polft University Proce, 2005
	 Ruijgrok, G.: Elements of Aircraft Pollution, Delft University Press, 2005 Friedrich, R., Reis, S.: Emissions of Air Pollutants, Springer 2004
	 Friedrich, K., Reis, S.: Emissions of Air Poliutants, Springer 2004 Janic, M.: The Sustainability of Air Transportation, Ashgate, 2007
	 Janic, M.: The Sustainability of Air Transportation, Asngate, 2007 Schumann, U. (ed.): Atmospheric Physics: Background - Methods - Trends, Springer, Berlin, Heidelberg, 2012
	 Schumann, U. (ed.): Atmospheric Physics: Background - Methods - Trends, Springer, Benin, Heidelberg, 2012 Spiridonov, V., Curic, M.: Fundamentals of Meteorology, Springer, 2021
	 Spindonov, V., Cunc, M.: rundamentals of Meteorology, Spiniger, 2021 Kaltschmitt, M., Neuling, U.: Biokerosene - Status and Prospects, Springer, 2018
	 Roedel, W., Wagner, T.: Physik unserer Umwelt: Die Atmosphäre, Springer, 2017 W. Bräunling: Flugzeugtriebwerke. Springer-Verlag Berlin, Deutschland, 2009 G. Brüning, X. Hafer, G. Sachs: Flugleistungen, Springer, 1993

•	Systems and Processes of Materials Testing
	Lecture
Hrs/wk	
CP	2
	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Dr. Jan Oke Peters
Language	DE
Cycle	SoSe
	 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	 E. Macherauch: Praktikum in Werkstoffkunde, Vieweg G. E. Dieter: Mechanical Metallurgy, McGraw-Hill R. Bürgel: Lehr- und Übungsbuch Festigkeitslehre, Vieweg R. Bürgel: Werkstoffe sícher beurteilen und richtig einsetzen, Vieweg

Course L2374: Mission Management	
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	60 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	SoSe
Content	
Literature	Brockhaus, Alles, Luckner: Flugregelung, Springer Verlag, 2011
	R.P.G Collinson: Introduction to Avionics Systems, Springer Verlag, 2011

Course L2375: Mission Management	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	60 min
scale	
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0908: Turbo Jet Eng	Course L0908: Turbo Jet Engines	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	45 min	
scale		
Lecturer	Dr. Burkhard Andrich	
Language	DE	
Cycle	WiSe	
Content	 Cycle of the gas turbine Thermodynamics of gas turbine components Wing-, grid- and stage-sizing Operating characteristics of gas turbine components Sizing criteria's for jet engines Development trends of gas turbines and jet engines Maintenance of jet engines 	
Literature	 Bräunling: Flugzeugtriebwerke Engmann: Technologie des Fliegens Kerrebrock: Aircraft Engines and Gas Turbines 	

Тур	Lecture
Hrs/wk	
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	WiSe
Content	Classical laminate theory
	Rules of mixture
	Failure mechanisms and criteria of composites
	Boundary value problems of isotropic and anisotropic shells
	Stability of composite structures
	Optimization of laminated composites
	Modelling composites in FEM
	Numerical multiscale analysis of textile composites
	Progressive failure analysis
Literature	 Schürmann, H., "Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. Wiedemann, J., "Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage. Reddy, J.N., "Mechanics of Composite Laminated Plates and Shells", CRC Publishing, Boca Raton et al., current edition. Jones, R.M., "Mechanics of Composite Materials", Scripta Book Co., Washington, current edition. Timoshenko, S.P., Gere, J.M., "Theory of elastic stability", McGraw-Hill Book Company, Inc., New York, current edition. Turvey, G.J., Marshall, I.H., "Buckling and postbuckling of composite plates", Chapman and Hall, London, current edition. Herakovich, C.T., "Mechanics of fibrous composites", John Wiley and Sons, Inc., New York, current edition. Mittelstedt, C., Becker, W., "Strukturmechanik ebener Laminate", aktuelle Auflage.

Course L1515: Structural Me	ourse L1515: Structural Mechanics of Fibre Reinforced Composites	
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Prof. Benedikt Kriegesmann	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1820: System Simul	Course L1820: System Simulation	
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
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	 Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7 M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011. 	

Course L1821: System Simulation	
Тур	Recitation Section (large)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
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	90 Minuten
scale	
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 I	Engineering Dynamics
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	90 min.
scale	
Lecturer	NN
Language	EN
Cycle	SoSe
Content	Method for calculation and testing of reliability of dynamic machine systems
	 Modeling System identification Simulation Processing of measurement data Damage accumulation Test planning and execution
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	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Examination Form	Klausur	
Examination duration and	90 min	
scale		
Lecturer	NN	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0749: Reliability of	Aircraft Systems
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek
Language	DE
Cycle	WiSe
Content	 Functions of reliability and safety (regulations, certification requirements) Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment) Reliability analysis of electrical and mechanical systems
Literature	 CS 25.1309 SAE ARP 4754 SAE ARP 4761

Supplement Modules Core Studies

Allows to obtain missing basic	s form bachelor studies. For further information, see	FSPO.		
Module M0960: Mech	anics IV (Oscillations, Analytical Mech	anics, Multibody Systems	s, Numerica	l Mechanics)
Courses				
Title		Тур	Hrs/wk	СР
Mechanics IV (Oscillations, Analytic	al Mechanics, Numerical Mechanics) (L1137)	Lecture	3	3
	al Mechanics, Numerical Mechanics) (L1138)	Recitation Section (small)	2	2
	al Mechanics, Numerical Mechanics) (L1139)	Recitation Section (large)	1	1
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous	Mathematics I-III and Mechanics I-III			
Knowledge				
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge	The students can			
	 describe the axiomatic procedure used in mecha 	nical contexts:		
	 explain important steps in model design; 			
	 present technical knowledge. 			
	P			
Skills	The students can			
	 explain the important elements of mathematical 	/ mechanical analysis and model for	mation and appl	v it to the context o
	their own problems;	, meenamear analysis and model for		y it to the context t
	 apply basic methods to engineering problems; 			
	 estimate the reach and boundaries of the method 	ds and extend them to be applicable t	o wider problem	sets.
Personal Competence				
	The students can work in groups and support each othe	r to overcome difficulties.		
social competence				
Autonomy	Students are capable of determining their own strength	s and weaknesses and to organize the	eir time and learn	ing based on those.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points				
Course achievement				
	Written exam			
Examination Examination duration and				
	120 min			
scale		star). Constitution Mashanian Frank	Commission Community	
-	General Engineering Science (German program, 7 seme		•	-
Following Curricula	5 5 1 1 5 1			bry
	General Engineering Science (German program, 7 seme Energy Systems: Technical Complementary Course Core		e. compuisory	
	Mechanical Engineering: Core qualification: Compulsory			
	Mechatronics: Core qualification: Compulsory			
	Naval Architecture: Core qualification: Compulsory			
	Technomathematics: Specialisation III. Engineering Scie	nce: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Complem		Compulsory	
	meeterieu neenaneu Engineering. reenneu eompien	lettive	comparativ	

Course L1137: Mechanics IV	(Oscillations, Analytical Mechanics, Numerical Mechanics)
Тур	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	SoSe
Content	
	 Elements of vibration theory Vibration of Multi-degree of freedom systems Analytical Mechanics Multibody Systems Numerical methods for time integration Introduction to Matlab
Literature	K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009). D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1-4. 11. Auflage, Springer (2011). W. Schiehlen, P. Eberhard: Technische Dynamik, Springer (2012).

Course L1138: Mechanics IV	Course L1138: Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics)		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	2		
Workload in Hours	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
CP	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

Module M0854: Math	ematics IV			
Courses				
Title		Tun	Hrs/wk	СР
	Typ Lecture	2	1	
Differential Equations 2 (Partial Differential Equations) (L1043) Differential Equations 2 (Partial Differential Equations) (L1044)		Recitation Section (small)	1	1
Differential Equations 2 (Partial Differential Equations) (L1045)		Recitation Section (large)	1	1
Complex Functions (L1038)		Lecture	2	1
Complex Functions (L1041)		Recitation Section (small)	1	1
Complex Functions (L1042)		Recitation Section (large)	1	1
Module Responsible				
Admission Requirements	None			
Recommended Previous	Mathematics 1 - III			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the foll	owing learning results		
Professional Competence Knowledge Skills	 Students can name the basic concepts in Mathematics Students can discuss logical connections between the the help of examples. They know proof strategies and can reproduce them. Students can model problems in Mathematics IV with 	ese concepts. They are capable	of illustrating th	ese connections wit
	 Students can induce problems in Mathematics to with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods. Students are able to discover and verify further logical connections between the concepts studied in the course. For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results. 			
Personal Competence Social Competence				
Autonomy	 Students are capable of checking their understanding of complex concepts on their own. They can specify open question precisely and know where to get help in solving them. Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on har problems. 			
Workload in Hours	Independent Study Time 68, Study Time in Lecture 112			
Credit points				
Course achievement				
	Written exam			
	60 min (Complex Functions) + 60 min (Differential Equations	2)		
scale				
Assignment for the	General Engineering Science (German program, 7 semester):	Specialisation Electrical Enginee	ering: Compulsor	у
Following Curricula	General Engineering Science (German program, 7 seme	ester): Specialisation Mechanica	al Engineering,	Focus Mechatronic
	Compulsory			
	General Engineering Science (German program, 7 semester):			
	General Engineering Science (German program, 7 semester)	: Specialisation Mechanical Engir	neering, Focus Th	neoretical Mechanic
	Engineering: Elective Compulsory			
	Computer Science: Specialisation Computational Mathematic	s: Elective Compulsory		
	Electrical Engineering: Core qualification: Compulsory			
	General Engineering Science (English program, 7 semester):			
	General Engineering Science (English program, 7 seme	ster): Specialisation Mechanica	l Engineering,	Focus Mechatronio
	Compulsory			
	General Engineering Science (English program, 7 semester):	Specialisation Mechanical Engir	neering, Focus Th	neoretical Mechanic
	Engineering: Compulsory			
	Computational Science and Engineering: Specialisation II. Ma		e: Elective Compu	llsory
	Mechanical Engineering: Specialisation Mechatronics: Compu	•		
	Mechanical Engineering: Specialisation Theoretical Mechanica	aı Engineering: Elective Compuls	ory	
	Mechatronics: Core qualification: Compulsory			
	Naval Architecture: Core qualification: Compulsory		Community	
	Theoretical Mechanical Engineering: Technical Complementa	ry course core studies: Elective	compulsory	

Course L1043: Differential Equations 2 (Partial Differential Equations)		
Тур	Lecture	
Hrs/wk	2	
CP	1	
Workload in Hours	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
Workload in Hours	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
Workload in Hours	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		
СР	1	
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28	
Lecturer	Dozenten des Fachbereiches Mathematik der UHH	
Language	DE	
Cycle	SoSe	
Content	Main features of complex analysis	
Literature	 Functions of one complex variable Complex differentiation Conformal mappings Complex integration Cauchy's integral theorem Cauchy's integral formula Taylor and Laurent series expansion Singularities and residuals Integral transformations: Fourier and Laplace transformation http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html 	
	http://www.math.uni-hamburg.de/teaching/export/tunh/index.html	

Course L1041: Complex Functions	
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	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
Workload in Hours	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				
Гitle		Тур	Hrs/wk	СР
ntroduction to Control Systems (L0)654)	Lecture	2	4
ntroduction to Control Systems (L0)655)	Recitation Section (small)	2	2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
	Representation of signals and systems in time and fre	equency domain, Laplace transform		
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	 Students can represent dynamic system behavior 	vior in time and frequency domain, and	can in particular	explain propertie
	first and second order systems			
	• They can explain the dynamics of simple contr	ol loops and interpret dynamic propertie	es in terms of free	quency response
	root locus			
	They can explain the Nyquist stability criterion	and the stability margins derived from i	t.	
	They can explain the role of the phase margin	in analysis and synthesis of control loop	S	
	They can explain the way a PID controller affect	cts a control loop in terms of its frequence	cy response	
	They can explain issues arising when controller	rs designed in continuous time domain a	are implemented	digitally
Skills				
011110	 Students can transform models of linear dynamic 	nic systems from time to frequency dom	ain and vice vers	а
	 They can simulate and assess the behavior of s 	systems and control loops		
	 They can design PID controllers with the help or 			
	They can analyze and synthesize simple control			
	 They can calculate discrete-time approximation 	ations of controllers designed in cor	itinuous-time an	d use it for di
	implementation			
	 They can use standard software tools (Matlab 0 	control roolbox, simulitik) for carrying o	ut these tasks	
Personal Competence				
Social Competence	Students can work in small groups to jointly solve tec	hnical problems, and experimentally val	idate their contro	ller designs
Autonomy	Students can obtain information from provided sour	rces (lecture notes, software document	ation, experimen	it guides) and us
	when solving given problems.			
	They can assess their knowledge in weekly on-line tes	sts and thereby control their learning pr	ogress	
	They can assess their knowledge in weekly on-line te	sts and thereby control then learning pr	ogress.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	56		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	General Engineering Science (German program, 7 ser	mester): Core qualification: Compulsory		
Following Curricula	Bioprocess Engineering: Core qualification: Compulso	ry		
	Computer Science: Specialisation Computational Math	hematics: Elective Compulsory		
	Data Science: Core qualification: Elective Compulsory	,		
	Electrical Engineering: Core qualification: Compulsory	/		
	Energy and Environmental Engineering: Core qualifica			
	General Engineering Science (English program, 7 sem	nester): Specialisation Electrical Enginee	ring: Compulsory	
	General Engineering Science (English program, 7 sem			
	General Engineering Science (English program, 7 sem			
	General Engineering Science (English program, 7 sem			ing: Compulsory
	General Engineering Science (English program, 7 sem			acus Biamasha
	General Engineering Science (English program, 7	semester): Specialisation Mechanica	i Engineering, F	ocus Biomecnar
	Compulsory General Engineering Science (English program, 7	semester): Specialisation Mechanical	Engineering For	us Energy Syste
	Compulsory	semestery. Specialisation rectionical	Lighteening, FUC	as Energy Syste
	General Engineering Science (English program, 7	semester): Specialisation Mechanical	Engineering For	us Aircraft Svst
	Engineering: Compulsory		.gg, 100	Second Syst
	· · · · ·		ooring Focus Mai	
	General Engineering Science (English program, 7 sem	nester): Specialisation Mechanical Engin	eening, rocus Mai	terials in Enginee
	General Engineering Science (English program, 7 sem Sciences: Compulsory	nester): Specialisation Mechanical Engin	eening, rocus Mai	terials in Enginee
			-	
	Sciences: Compulsory		-	
	Sciences: Compulsory General Engineering Science (English program, 7	7 semester): Specialisation Mechanica	al Engineering, I	Focus Mechatror

G	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical
E	ngineering: Compulsory
G	General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory
G	General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory
G	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory
G	Green Technologies: Energy, Water, Climate: Core qualification: Compulsory
C	Computational Science and Engineering: Core qualification: Compulsory
Lo	ogistics and Mobility: Specialisation Engineering Science: Elective Compulsory
Lo	ogistics and Mobility: Specialisation Information Technology: Elective Compulsory
Lo	ogistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory
Lo	ogistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory
М	Aechanical Engineering: Core qualification: Compulsory
м	Achatronics: Core qualification: Compulsory
Т	echnomathematics: Specialisation III. Engineering Science: Elective Compulsory
Т	heoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory
P	Process Engineering: Core qualification: Compulsory
E	ingineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory
E	ingineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory
E	ingineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective
C	Compulsory

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 plots
	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	
	Werner, H., Lecture Notes "Introduction to Control Systems"
	G.F. Franklin, J.D. Powell and A. Emami-Naeini "Feedback Control of Dynamic Systems", Addison Wesley, Reading, MA, 2
	 K. Ogata "Modern Control Engineering", Fourth Edition, Prentice Hall, Upper Saddle River, NJ, 2010 R.C. Dorf and R.H. Bishop, "Modern Control Systems", Addison Wesley, Reading, MA 2010

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		Тур	Hrs/wk	СР
Numerical Mathematics I (L0417)		Lecture	2	3
Numerical Mathematics I (L0418)		Recitation Section (small)	2	3
Module Responsible	Prof. Sabine Le Borne			
Admission Requirements	None			
Recommended Previous				
Knowledge	Mathematik I + II for Engineering Students (germ basic MATLAB/Python knowledge	ian or english) or Analysis & Linear Alg	jebra I + II for Te	chnomathematici
Educational Objectives Professional Competence	After taking part successfully, students have reached th	ne following learning results		
•	Students are able to			
	 name numerical methods for interpolation, integ problems and to explain their core ideas, repeat convergence statements for the numerication explain aspects for the practical execution of numerication. 	al methods,		
Skills	Students are able to			
	 implement, apply and compare numerical metho justify the convergence behaviour of numerical r select and execute a suitable solution approach 	nethods with respect to the problem ar	nd solution algori	thm,
Personal Competence				
Social Competence	Students are able to			
	work together in heterogeneously composed tea avalations and support each			
	explain theoretical foundations and support each	i other with practical aspects regarding	the implementa	tion of algorithms
Autonomy	Students are capable			
	to assess whether the supporting theoretical andto assess their individual progess and, if necessa		individually or in	a team,
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
	General Engineering Science (German program, 7 seme	ester): Specialisation Computer Science	e: Compulsory	
Assignment for the				Focus Materials
Assignment for the	General Engineering Science (German program, 7 seme			Focus Materials
Assignment for the	General Engineering Science (German program, 7 seme General Engineering Science (German program, 7	semester): Specialisation Mechanic	al Engineering,	
Assignment for the	General Engineering Science (German program, 7 seme General Engineering Science (German program, 7 Engineering Sciences: Compulsory General Engineering Science (German program, 7 seme General Engineering Science (German program, 7	semester): Specialisation Mechanic	al Engineering, eering: Compulso	ory
Assignment for the	General Engineering Science (German program, 7 seme General Engineering Science (German program, 7 Engineering Sciences: Compulsory General Engineering Science (German program, 7 seme	semester): Specialisation Mechanic	al Engineering, eering: Compulso	ory
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Assignment for the	General Engineering Science (German program, 7 seme General Engineering Science (German program, 7 Engineering Sciences: Compulsory General Engineering Science (German program, 7 seme General Engineering Science (German program, 7 Compulsory General Engineering Science (German program, 7 seme Engineering: Compulsory	semester): Specialisation Mechanic ester): Specialisation Biomedical Engine semester): Specialisation Mechanical ester): Specialisation Mechanical Engin	al Engineering, eering: Compulsc Engineering, F eering, Focus Th	ory Focus Biomechan Reoretical Mechan
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Assignment for the	General Engineering Science (German program, 7 seme General Engineering Science (German program, 7 Engineering Sciences: Compulsory General Engineering Science (German program, 7 seme General Engineering Science (German program, 7 seme General Engineering Science (German program, 7 seme Engineering: Compulsory General Engineering Science (German program, 7 seme Engineering: Compulsory General Engineering Science (German program, 7 seme Engineering: Elective Compulsory General Engineering Science (German program, 7 seme Compulsory General Engineering Science (German program, 7 seme Compulsory General Engineering Science (German program, 7 seme Compulsory Bioprocess Engineering: Specialisation A - General Biop Computer Science: Specialisation Computational Mathee Computer Science: Specialisation II. Mathematics and E Data Science: Core qualification: Compulsory Electrical Engineering: Core qualification: Compulsory Engineering Science: Core qualification: Compulsory Engineering Science: Core qualification: Compulsory General Engineering Science (English program, 7 seme General Engineering Science (English program, 7 seme	semester): Specialisation Mechanic ester): Specialisation Biomedical Engine semester): Specialisation Mechanical ester): Specialisation Mechanical Engin emester): Specialisation Mechanical Engin encess Engineering: Elective Compulso matics: Elective Compulsory ngineering Science: Elective Compulso pulsory ster): Core qualification: Compulsory ster): Specialisation Computer Science semester): Specialisation Mechanical	al Engineering, eering: Compulso Engineering, Focus Th Engineering, Focus Th Engineering, Focus M Engineering, Foc ry ry : Compulsory Engineering, F	ory Focus Biomechan Reoretical Mechan Rus Aircraft Syste echatronics: Elect us Energy System
Assignment for the	General Engineering Science (German program, 7 seme General Engineering Science (German program, 7 Engineering Sciences: Compulsory General Engineering Science (German program, 7 seme General Engineering Science (German program, 7 seme General Engineering Science (German program, 7 seme Engineering: Compulsory General Engineering Science (German program, 7 seme Engineering: Compulsory General Engineering Science (German program, 7 seme Engineering: Elective Compulsory General Engineering Science (German program, 7 seme Compulsory General Engineering Science (German program, 7 seme Compulsory General Engineering Science (German program, 7 seme Compulsory Bioprocess Engineering: Specialisation A - General Biop Computer Science: Specialisation Computational Mathee Computer Science: Specialisation II. Mathematics and E Data Science: Core qualification: Compulsory Electrical Engineering: Core qualification: Compulsory Engineering Science: Core qualification: Compulsory General Engineering Science (English program, 7 seme General Engineering Science (English program, 7 seme General Engineering Science (English program, 7 seme General Engineering Science (English program, 7 seme	semester): Specialisation Mechanic ester): Specialisation Biomedical Engine semester): Specialisation Mechanical ester): Specialisation Mechanical Engin emester): Specialisation Mechanical Engin encess Engineering: Elective Compulso matics: Elective Compulsory ngineering Science: Elective Compulso pulsory ster): Core qualification: Compulsory ster): Specialisation Computer Science semester): Specialisation Mechanical	al Engineering, eering: Compulso Engineering, Focus Th Engineering, Focus Th Engineering, Focus M Engineering, Foc ry ry : Compulsory Engineering, F	ory Focus Biomechan Reoretical Mechan Rus Aircraft Syste echatronics: Elect us Energy System

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
General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective
Compulsory
Computational Science and Engineering: Core qualification: Compulsory
Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory
Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory
Mechanical Engineering: Specialisation Mechatronics: 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	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Sabine Le Borne	
Language	EN	
Cycle	WiSe	
Content	 Finite precision arithmetic, error analysis, conditioning and stability Linear systems of equations: LU and Cholesky factorization, condition Interpolation: polynomial, spline and trigonometric interpolation Nonlinear equations: fixed point iteration, root finding algorithms, Newton's method Linear and nonlinear least squares problems: normal equations, Gram Schmidt and Householder orthogonalization, singular value decomposition, regularizatio, Gauss-Newton and Levenberg-Marquardt methods Eigenvalue problems: power iteration, inverse iteration, QR algorithm Numerical differentiation Numerical integration: Newton-Cotes rules, error estimates, Gauss quadrature, adaptive quadrature 	
Literature	 Gander/Gander/Kwok: Scientific Computing: An introduction using Maple and MATLAB, Springer (2014) Stoer/Bulirsch: Numerische Mathematik 1, Springer Dahmen, Reusken: Numerik f ür Ingenieure und Naturwissenschaftler, Springer 	

Course L0418: Numerical Ma	thematics I
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, Dr. Jens-Peter Zemke
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Thesis

Master Thesis	
Module M-002: Maste	er Thesis
Courses	
	Typ Hrs/wk CP
Title	
Module Responsible	Professoren der TUHH
Admission Requirements	According to General Regulations §21 (1):
	At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous	
Knowledge	
	After taking part successfully, students have reached the following learning results
Professional Competence	· · · · · · · · · · · · · · · · · · ·
Knowledge	
hitemedge	• The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specializ
	issues.
	• The students can explain in depth the relevant approaches and terminologies in one or more areas of their subje
	describing current developments and taking up a critical position on them.
	 The students can place a research task in their subject area in its context and describe and critically assess the state
	research.
Skills	The students are able:
	To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question
	 To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and,
	incompletely defined problems in a solution-oriented way.
	 To develop new scientific findings in their subject area and subject them to a critical assessment.
Personal Competence	
Social Competence	Students can
	Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structur
	Way.
	 Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addresse
	while upholding their own assessments and viewpoints convincingly.
Autonomy	Students are able:
	 To structure a project of their own in work packages and to work them off accordingly.
	 To work their way in depth into a largely unknown subject and to access the information required for them to do so.
	 To apply the techniques of scientific work comprehensively in research of their own.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	
Course achievement	
Examination	
	According to General Regulations
scale	
-	Civil Engineering: Thesis: Compulsory
Following Curricula	
	Chemical and Bioprocess Engineering: Thesis: Compulsory
	Computer Science: Thesis: Compulsory
	Electrical Engineering: Thesis: Compulsory
	Energy and Environmental Engineering: Thesis: Compulsory
	Energy Systems: Thesis: Compulsory
	Environmental Engineering: Thesis: Compulsory
	Aircraft Systems Engineering: Thesis: Compulsory
	Global Innovation Management: Thesis: Compulsory
	Computational Science and Engineering: Thesis: Compulsory
	Information and Communication Systems: Thesis: Compulsory
	Interdisciplinary Mathematics: Thesis: Compulsory
	International Management and Engineering: Thesis: Compulsory
	Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory
	Logistics, Infrastructure and Mobility: Thesis: Compulsory Materials Science: Thesis: Compulsory
	naterials selence. Inclus. compulsory

Mechanical Engineering and Management: Thesis: Compulsory
Mechatronics: Thesis: Compulsory
Biomedical Engineering: Thesis: Compulsory
Microelectronics and Microsystems: Thesis: Compulsory
Product Development, Materials and Production: Thesis: Compulsory
Renewable Energies: Thesis: Compulsory
Naval Architecture and Ocean Engineering: Thesis: Compulsory
Ship and Offshore Technology: Thesis: Compulsory
Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory
Theoretical Mechanical Engineering: Thesis: Compulsory
Process Engineering: Thesis: Compulsory
Water and Environmental Engineering: Thesis: Compulsory
Certification in Engineering & Advisory in Aviation: Thesis: Compulsory