

Module Manual

Master of Science (M.Sc.)

Theoretical Mechanical Engineering

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Program description

Content

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

Career prospects

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

Learning target

The graduates can:

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

Graduates are able to:

• develop concepts and solutions to basic research, partly unusual problems, possibly involving other disciplines,

· create and develop new products, processes and methods

• apply their scientific engineering judgment to work with complex, possibly incomplete information, to identify contradictions and deal with them

- classify knowledge from different fields methodically and systematically, to combine and handle complexity;
- familiarize themselves systematically, and in a short time frame, with new tasks
 - To reflect systematically the non-technical implications of engineering activity and to act responsibly



• to develop solutions and further methodological skills.

Program structure

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

The curricular content is thus divided into six groups:

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

The areas of specialization are:

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

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

Core qualification

mportant	
Module M0523: B	Business & Management
	Jusiness & Management
Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	 Students are able to find their way around selected special areas of management within the scope of business management. 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 management.
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	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
	The Nontechnical Academic Programms (NTA)
	imparts skills that, in view of the TUHH's training profile, professional engineering studi require but are not able to cover fully. Self-reliance, self-management, collaboration a professional and personnel management competences. The department implements the training objectives in its teaching architecture , in its teaching and learning arrangements , teaching areas and by means of teaching offerings in which students can qualify by opting specific competences and a competence level at the Bachelor's or Master's level. T teaching offerings are pooled in two different catalogues for nontechnical complementa courses.
	The Learning Architecture
	consists of a cross-disciplinarily study offering. The centrally designed teaching offeri ensures that courses in the nontechnical academic programms follow the specific profiling TUHH degree courses.
	The learning architecture demands and trains independent educational planning as regare the individual development of competences. It also provides orientation knowledge in the for of "profiles".
	The subjects that can be studied in parallel throughout the student's entire study program need be, it can be studied in one to two semesters. In view of the adaptation problems the individuals commonly face in their first semesters after making the transition from school university and in order to encourage individually planned semesters abroad, there is obligation to study these subjects in one or two specific semesters during the course studies.
	Teaching and Learning Arrangements
	provide for students, separated into B.Sc. and M.Sc., to learn with and from each other acro semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learni in courses are part of the learning architecture and are deliberately encouraged in speci courses.
Knowledge	Fields of Teaching
omougo	are based on research findings from the academic disciplines cultural studies, social studie arts, historical studies, communication studies, migration studies and sustainability researce and from engineering didactics. In addition, from the winter semester 2014/15 students on Bachelor's courses will have the opportunity to learn about business management and sta ups in a goal-oriented way.
	The fields of teaching are augmented by soft skills offers and a foreign language offer. He the focus is on encouraging goal-oriented communication skills, e.g. the skills required outgoing engineers in international and intercultural situations.
	The Competence Level

Module M0524: Nontechnical Elective Complementary Courses for Master

	of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc.
	This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life.
	Specialized Competence (Knowledge)
	Students can
	 explain specialized areas in context of the relevant non-technical disciplines, outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area, different specialist disciplines relate to their own discipline and differentiate it as well as make connections, sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity, Can communicate in a foreign language in a manner appropriate to the subject.
	Professional Competence (Skills)
	In selected sub-areas students can
Skills	 apply basic and specific methods of the said scientific disciplines, aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline, to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner, justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.
Personal Competence	
	Students will be able
Social Competence	 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).
	Personal Competences (Self-reliance) Students are able in selected areas
	 to reflect on their own profession and professionalism in the context of real-life fields of

Autonomy	 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	Depends on choice of courses
Credit points	6

Courses

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

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	Technical Complementary bject Specific Regulations)	Course	Core	Studies	for	TMBMS
Courses						
Title		Тур		Hrs/v	vk	СР
Module Responsible						
Admission Requirements	None					
Recommended Previous Knowledge	see FSPO					
Educational Objectives	After taking part successfully, students ha	ve reached t	he follow	ing learning I	results	5
Professional Competence						
Knowledge	see FSPO					
Skills	see FSPO					
Personal						
Competence						
Social Competence						
-	see FSPO					
	Independent Study Time 180, Study Time	e in Lecture 0				
Credit points						
Course achievement						
	according to Subject Specific Regulation	S				
Examination duration and scale	see FSPO					
Assignment for the Following Curricula	Theoretical Mechanical Engineering: Con	re qualificatio	on: Electiv	e Compulso	ſУ	

Module M0751: V	'ibration Theory				
Courses					
Title Vibration Theory (L0701)	TypHrs/wkCPIntegrated Lecture46				
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	 Calculus Linear Algebra Engineering 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 Vibration Theory and develop them furthe				
Skills	Students are able to denote methods of Vibration Theory and develop them further.				
Personal					
Competence					
	Students can reach working results also in groups.				
	Students are able to approach individually research tasks in Vibration Theory.				
	Independent Study Time 124, Study Time in Lecture 56				
Credit points Course achievement					
	Written exam				
Examination duration and scale					
-	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Electiv Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsor Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Electiv Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Electiv Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Electiv Compulsory Biomedical Engineering: Specialisation Core qualification: Compulsory Product Development, Materials and Production: Core qualification: Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory				

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			Тур	Hrs/wk	СР
Finite Element Methods (Lu Finite Element Methods (Lu	,		Lecture Recitation Section (2 (large) 2	3 3
Module Responsible					0
Admission					
Requirements					
Recommended Previous Knowledge	Dynamics)		laterials) and Mechanics ntial equations)	s II (Hydrostatic	s, Kinematic
Educational Objectives	After taking part succe	essfully, students	have reached the following	ng learning resu	lts
Professional					
Competence					
	•	•	owledge regarding the d erview of the theoretical		
Knowledge					
	elements, assembling equations.	The correspondi	ng system matrices, and	Solving the resu	ning system
Personal Competence					
Social Competence	Students can work in s	small groups on s	specific problems to arrive	e at joint solutior	IS.
		•	ently solve challenging Problems can be identifie	•	•
Auonomy					
Workload in Hours	Independent Study Tir	me 124, Study Tir	me in Lecture 56		
Credit points	6				
Course achievement	Compulsory BonusNo20 %	Form Midterm	Desc	cription	
Examination	Written exam				
Examination duration and scale	120 min				

	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory
Assignment for the Following Curricula	Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Product Development, Materials and Production: Core qualification: Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory

Course L0291: Finite E	Element 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 E	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			

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courses					
Title		Тур	Hrs/wk	СР	
Control Systems Theory a Control Systems Theory a		Lecture Recitation Section	2 (small) 2	4 2	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous Knowledge	Introduction to Control Systems				
Educational Objectives	After taking part successfully, students	s have reached the following	ng learning resu	ilts	
Professional Competence					
Knowledge	 Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively They can explain the significance of a minimal realisation They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection They can explain the z-transform and its relationship with the Laplace Transform They can explain state space models and transfer function models of discrete-time systems They can explain the experimental identification of ARX models of dynamic systems and how the identification problem can be solved by solving a normal equation They can explain how a state space model can be constructed from a discrete-time impulse response 				
Skills	 Students can transform transfer function models into state space models and v versa They can assess controllability and observability and construct minimal realisations They can design LQG controllers for multivariable plants They can carry out a controller design both in continuous-time and discrete-til domain, and decide which is appropriate for a given sampling rate They can identify transfer function models and state space models of dynamic syste from experimental data They can carry out all these tasks using standard software tools (Matlab Cont Toolbox, System Identification Toolbox, Simulink) 				
Personal Competence					
Social Competence	Studente con work in small groupe on	specific problems to arrive	e at joint solutior	ıs.	
	Students can obtain information documentation, experiment guides) a	-	•	otes, softwar	
Autonomy	They can assess their knowledge in progress.	weekly on-line tests and	thereby contro	I their learnin	

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Core qualification: Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory



Course L0656: Contro	I Systems Theory and Design
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
	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
Content	Pole placement for multivariable systems, LQR design, Kalman filter
Contoni	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
	Morpor H. Losturo Notos, Control Sustano Theory, and Design"
	 Werner, H., Lecture Notes "Control Systems Theory and Design" T. Kailath "Linear Systems", Prentice Hall, 1980
Literature	 Kallatin Linear Systems , Prentice Hall, 1960 K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997
	 L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

Course L0657: Contro	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	(1.1000)	Тур	Hrs/wk	СР		
Flexible Multibody Systems Optimization of dynamical		Lecture Lecture	2 2	3 3		
Module Responsible	· · · ·					
Admission Requirements						
Recommended Previous Knowledge	 Mathematics I, II, III Mechanics I, II, III, IV Simulation of dynamical Systems 					
Educational Objectives	After taking part successfully, stu	dents have reached the follow	ving learning resu	lts		
Professional Competence						
Knowledae	Students demonstrate basic kr analysis of complex rigid and fle systems after successful complet	xible multibody systems and	g of modeling, s methods for optim	imulation an nizing dynam		
	Students are able					
	+ to think holistically					
	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody systems					
	+ to describe dynamics problems mathematically					
	+ to optimize dynamics problems					
Personal Competence						
ĺ	Students are able to					
Social Competence	+ solve problems in heterogeneous groups and to document the corresponding results.					
	Students are able to					
	+ assess their knowledge by means of exercises.					
Autonomy	+ acquaint themselves with the r	necessary knowledge to solve	research oriented	d tasks.		
Workload in Hours	Independent Study Time 124, Stu	udy Time in Lecture 56				
Credit points		,				
Course achievement						
Examination	Oral exam					
Examination duration and scale	30 min					

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

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Course L1632: Flexible	e Multibody 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	 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: Optimiz	zation 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, Dr. Leo Dostal
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.

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Module M0939: C	Contro	I Lab A				
Courses						
Title				Тур	Hrs/wk	СР
Control Lab I (L1093)				Practical Course	1 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. H	erbert Werner				
Admission Requirements	Nono					
Recommended Previous Knowledge	•	State space methods LQG control H2 and H-infinity optir uncertain plant model LPV control		ntrol		
Educational Objectives	Affer ta	king part successfully,	students have r	eached the following	g learning resu	Its
Professional Competence						
Knowledge		Students can explain and experimental vali		between validation o	of a control lop	o in simulation
Skills	 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers 					
Personal Competence						
Social Competence	•	Students can work in t	teams to conduc	t experiments and d	ocument the re	sults
Autonomy	 Students can independently carry out simulation studies to design and validate control loops 					
Workload in Hours	Indepe	ndent Study Time 64,	Study Time in Le	ecture 56		
Credit points	4					
Course achievement	None					
Examination	Written	elaboration				
Examination duration and scale	11					
		al Engineering: Spe	cialisation Cont	rol and Power Sys	stems Enginee	ering: Elective

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

Course L1093: Contro	I 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.
	Experiment Guides
Literature	

Course L1291: Contro	l 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: Contro	ourse L1665: Control Lab 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			
	One of the offered experiments in control theory.			
Literature	Experiment Guides			

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
	One of the offered experiments in control theory.
Literature	Experiment Guides

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	a manal Lack O					
Module M1306: C	ontrol Lad C	,				
Courses						
Title			Тур		Hrs/wk	СР
Control Lab IX (L1836)			Practical		1	1
Control Lab VII (L1834)			Practical		1	1
Control Lab VIII (L1835)			Practical	Course	1	1
Module Responsible Admission		rner				
Requirements	None					
Recommended Previous Knowledge		rol -infinity optimal co plant models and				
Educational Objectives	After taking part s	successfully, stude	nts have reached th	e following	learning resul	lts
Professional Competence						
Knowledge		can explain the d rimental validation	ifference between	validation o	f a control lop	in simulatio
Skills	ldentificat synthesis They are design an They are the mixed They are implemen They are	ion Toolbox) to id capable of using ad implementation capable of using s l-sensitivity design e capable of re- nting a robust contr capable of using s	pplying basic syste dentify a dynamic standard software of LQG controllers standard software to and the implement presenting model roller standard software to entation of LPV gain	model that tools (Matl ols (Matlab ation of H-ir uncertainty ols (Matlab	can be used ab Control To Robust Contro offinity optimal of y, and of do Robust Contro	for controlle polbox) for th ol Toolbox) fo controllers esigning an
Personal Competence						
Social Competence	Students	can work in teams	to conduct experim	ents and do	ocument the re	sults
Autonomy	• Students loops	can independently	/ carry out simulatio	n studies to	design and v	alidate contro
Workload in Hours	Independent Stud	dy Time 48, Study	Time in Lecture 42			
Credit points	3					
Course achievement	None					
	Written elaboratio	on				
Examination duration						
and scale						
		eering: Specialisa	tion Control and	Power Sys	tems Enginee	ering: Electiv
Assignment for the	Compulsory Mechatronics: Sp	ecialisation Intellig	gent Systems and F	lobotics: Ele	ective Compuls	sory

Following Curricula Mechatronics: Specialisation System Design: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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Course L1836: Contro	I 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
	One of the offered experiments in control theory.
Literature	Experiment Guides

Course L1834: Contro	I 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
	WiSe/SoSe
	One of the offered experiments in control theory.
Literature	Experiment Guides

Course L1835: Control Lab VIII		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
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	
	One of the offered experiments in control theory.	
Literature	Experiment Guides	



Courses				
Fitle		Тур	Hrs/wk	СР
Continuum Mechanics (L1 Continuum Mechanics Ex	-	Lecture Recitation Section (small)	2	3 3
Module Responsible			_	-
Admission				
Requirements	None			
Recommended Previous Knowledge	Basics of linear continuum mechanics as taug moments, stress, linear strain, free-body pr energy).			
Educational Objectives	After taking part successfully, students have re-	ached the following lea	rning results	8
Professional				
Competence				
Knowledge	The students can explain the fundamental co materials.	ncepts to calculate the	mechanica	l behavior (
Skills	The students can set up balance laws and aspects, both in applied contexts as in researc		nation theor	y to specif
Personal Competence				
	The students are able to develop solutions, to	present them to special	sts in writte	n form and
Social Competence	develop ideas further.			
Autonomy	The students are able to assess their of independently and on their own identify ar mechanics and acquire the knowledge require	nd solve problems in		-
Workload in Hours	Independent Study Time 124, Study Time in Le	ecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: El Mechanical Engineering and Management: Sp Mechatronics: Technical Complementary Cour Biomedical Engineering: Specialisation Artifici Compulsory Biomedical Engineering: Specialisation Implar Biomedical Engineering: Specialisation Med Compulsory	ecialisation Materials: I se: Elective Compulsor al Organs and Regene	y rative Medio s: Elective C	cine: Electiv



Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L1533: Continu	uum Mechanics
Тур	Lecture
Hrs/wk	2
CP	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

Course L1534: Continu	uum Mechanics Exercise
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	 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	h. (1.0500)		Тур	Hrs/wk	СР
Boundary Element Methods (L0523) Boundary Element Methods (L0524)			Lecture Recitation Section (large)	2 2	3 3
Module Responsible	Prof. Otto von Estorff				
Admission Requirements	None				
Recommended Previous Knowledge	Mechanics I (Statics, Mec Dynamics) Mathematics I, II, III (in parti			lydrostatics	, Kinematic
Educational Objectives	After taking part successful	ly, students have re	ached the following lea	rning resul	İS
Professional					
Competence	The students persons on	in-depth knowled	ao roaardina tho dow	vation of t	ha haunda
	The students possess an element method and are a	•			
Knowledge	the method.				
Knowledge					
Skills	elements, assembling the equations.	corresponding syste	em matrices, and solvin	g the resul	ing system
Personal Competence					
Social Competence	Ctudente con work in emall	groups on specific	problems to arrive at joi	nt solutions	3.
Autonomy	The students are able to develop own boundary e critically scrutinized.	•		•	
Workload in Hours	Independent Study Time 12	24, Study Time in Le	ecture 56		
Credit points	6				
Course achievement		Form Midterm	Descriptio	n	
Examination	Written exam				
Examination duration and scale	90 min				
	Civil Engineering: Speciali Civil Engineering: Speciali				v



Assignment for the	Mechanical	Engineering	and	Management:	Specialisation	Product	Development	and
Following Curricula	Production: I	Elective Comp	ulsor	Ý				
i onoring ourrould	Mechatronic	s: Specialisati	on Sy	stem Design: Ele	ective Compulso	ry		
	Product Dev	elopment, Mat	erials	and Production	: Core qualificati	on: Electiv	ve Compulsory	
	Technomath	ematics: Spec	ialisa	tion III. Engineer	ing Science: Ele	ctive Corr	npulsory	
	Theoretical N	/lechanical Er	ginee	ering: Core quali	fication: Elective	Compuls	ory	
	Theoretical N	lechanical Er	ginee	ering: Technical	Complementary	Course: E	Elective Compul	lsory

Course L0523: Bound	ary Element 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
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: Bounda	Course 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			

Courses					
Title Numerical Treatment of O	-	Differential Equations (L0576) Differential Equations (L0582)	Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. S	abine Le Borne			
Admission Requirements	None				
Recommended Previous Knowledge		Mathematik I, II, III für Ingenieurs Lineare Algebra I + II sowie Analy Basic MATLAB knowledge		- ,	ler Analysis
Educational Objectives	After ta	aking part successfully, students ha	ave reached the following lea	rning resul	lts
Professional Competence					
Knowledge	 explain aspects regarding the practical execution of a method. select the appropriate numerical method for concrete problems, implement the numerical algorithms efficiently and interpret the numerical results 				
Skills	 Students are able to implement (MATLAB), apply and compare numerical methods for the solution ordinary differential equations, to justify the convergence behaviour of numerical methods with respect to the pose problem and selected algorithm, for a given problem, develop a suitable solution approach, if necessary by the composition of several algorithms, to execute this approach and to critically evaluat the results. 				
Personal Competence	Stude	nts are able to			
Social Competence	work together in beterogeneously composed teams (i.e. teams from different stur				
Autonomy	 Students are capable to assess whether the supporting theoretical and practical excercises are better solved individually or in a team, to assess their individual progress and, if necessary, to ask questions and seek help. 				
		endent Study Time 124, Study Time	e in Lecture 56		
Credit points	6				

	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Energy Systems' Core dualification' Elective Compulsory

Course L0576: Numer	ical Treatment of Ordinary Differential Equations				
Тур	Lecture				
Hrs/wk					
СР					
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Lecturer	Prof. Sabine Le Borne, Dr. Christian Seifert				
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: Nonstif Problems E. Hairer, G. Wanner: Solving Ordinary Differential Equations II: Stiff and Differential- Algebraic Problems 				

Course L0582: Numer	Course L0582: Numerical Treatment of Ordinary Differential Equations		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	f. Sabine Le Borne, Dr. Christian Seifert		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses						
Title		Ţ	/p	Hrs/wk	СР	
Lab Applied Dynamics (L [.] Applied Dynamics (L1630			actical Course	3 2	3 3	
Module Responsible	, 			-	0	
Admission						
Requirements						
Recommended Previous Knowledge	Mathematics I, II, III, Med					
-		Ordinary Differential Equ	lations			
Educational Objectives	After taking part succes	sfully, students have reac	hed the following	learning resu	lts	
Professional						
Competence Knowledge	Students can represent the most important methods of dynamics after successful completion					
	Students are able					
	+ to think holistically					
Skills	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody systems					
	+ to describe dynamics problems mathematically					
	+ to investigate dynamics problems both experimentally and numerically					
Personal						
Competence						
	Students are able to					
Social Competence	+ solve problems in heterogeneous groups and to document the corresponding results.					
	Students are able to					
	+ assess their knowledge by means of exercises and experiments.					
Autonomy	+ acquaint themselves with the necessary knowledge to solve research oriented tasks.					
Workload in Hours Credit points	· · ·	e 110, Study Time in Lec	ure /U			
	Compulsory Bonus	Form	Descri	ption		
Course achievement		Subject theoretica practical work		he Fachlabor		
Examination	Written exam					
Examination duration and scale	90 min					

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Course L1631: Lab Ap	plied Dynamics
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.

Tvn	Lecture
Hrs/wk	
CP	
	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: Wiesbader 2014. Woernle, C.: Mehrkörpersysteme, Springer: Heidelberg, 2011. Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.

Module M0752: N	Ionlinear Dynamics					
Courses						
Title Nonlinear Dynamics (L07	02)	Typ Integrated Lecture	Hrs/wk 4	CP 6		
	Prof. Norbert Hoffmann					
Admission Requirements	None					
Recommended Previous Knowledge	 Linear Algebra 					
Educational Objectives	After taking part successfully, students have	reached the following I	earning resu	ts		
Professional Competence			–			
Knowledge	develop and research new terms and conce	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.				
Skills	develop novel methods and procedures.	Is and procesures of N	Ionlinear Dyi	namics and to		
Personal Competence						
-	Students can reach working results also in g	roups.				
Autonomy	Students are able to approach given resear novel research tasks by themselves.	rch tasks individually a	nd to identify	and follow up		
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56				
Credit points	6					
Course achievement	None					
Examination	Written exam					
Examination duration and scale	2 Hours					
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation International Management and Enginee Compulsory Mechanical Engineering and Management: Mechatronics: Specialisation System Design Mechatronics: Specialisation Intelligent Syst Biomedical Engineering: Specialisation Artif Compulsory Biomedical Engineering: Specialisation Imp Biomedical Engineering: Specialisation Ma Compulsory Biomedical Engineering: Specialisation Ma Compulsory Biomedical Engineering: Specialisation Ma Compulsory Product Development, Materials and Product Theoretical Mechanical Engineering: Core of	ring: Specialisation I Specialisation Mechatr h: Elective Compulsory ems and Robotics: Elec ficial Organs and Rege lants and Endoprosthes edical Technology and magement and Busine stion: Core qualification ical Complementary Co	II. Mechatron onics: Elective ctive Comput- nerative Med ses: Elective d Control Th ess Administr : Elective Con purse: Elective	nics: Elective e Compulsory licine: Elective Compulsory eory: Elective ation: Elective		

Course L0702: Nonline	ourse 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 Humanoid Robotics (L066	3)			Typ Seminar	Hrs/wk 2	CP 2
Module Responsible	Patrick	Göttsch				
Admission Requirements	None					
Recommended Previous Knowledge		Introduction to c Control theory a	•			
Educational Objectives	After ta	king part succes	sfully, students	have reached the follow	ing learning resu	lts
Professional Competence						
Knowledge		Students can e Students learn t	•	d robots. ontrol concepts for differe	ent tasks in huma	noid robotics.
Skills	 Students acquire knowledge about selected aspects of humanoid robotics, based or specified literature Students generalize developed results and present them to the participants Students practice to prepare and give a presentation 					
Personal Competence						
Social Competence		them	to provide app	loping solutions in inter propriate feedback and I		•
Autonomy		specific tasks an Students familia	nd select the be trize themselve	s and drawbacks of diff est solution s with a scientific field, an s, such that a scientific dis	re able of introduc	ce it and follo
Workload in Hours	Indepe	ndent Study Tim	e 32, Study Tir	ne in Lecture 28		
Credit points	2					
Course achievement	None					
Examination	Preser	itation				
Examination duration and scale	30 min					
Assignment for the Following Curricula	Mecha Biomed Compu Biomed Biomed Compu	tronics: Speciali dical Engineerin Ilsory dical Engineerin dical Engineerir Ilsory	sation System I g: Specialisatio	nt Systems and Robotics Design: Elective Compute on Artificial Organs and F on Implants and Endopro on Medical Technology	sory Regenerative Mec stheses: Elective and Control Th	licine: Elective Compulsory leory: Elective

Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L0663: Human	oid 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 Linear and Nonlinear Syst	tem Identification (L0660)	Typ Lecture	Hrs/wk 2	СР 3
	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	 Classical control (frequency State space methods Discrete-time systems Linear algebra, singular val Basic knowledge about stoc 	ue decomposition		
Educational Objectives	After taking part successfully, stude	nts have reached the follow	ving learning resu	lts
Professional Competence				
Knowledge	 Students can explain the general framework of the prediction error method and i application to a variety of linear and nonlinear model structures They can explain how multilayer perceptron networks are used to model nonlinear dynamics They can explain how an approximate predictive control scheme can be based on neural network models They can explain the idea of subspace identification and its relation to Kalma realisation theory 			
Skills	 Students are capable of a identification of linear and n They are capable of impler neural network model They are capable of applyir linear models for dynamic s They can do the above us Identification Toolbox) 	onlinear models for dynami nenting a nonlinear predict ng subspace algorithms to th ystems	ic systems tive control scherr he experimental id	ne based on dentification
Personal Competence				
Social Competence	Students can work in mixed groups	on specific problems to arr	ive at joint solutio	ıs.
Autonomy	Students are able to find required software documentation) and use it		ovided (lecture no	otes, literatur
Workload in Hours	Independent Study Time 62, Study	Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
	30 min		-	-

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

Course L0660: Linear	and Nonlinear System Identification
Тур	Lecture
Hrs/wk	2
СР	3
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

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Module M0657: C	Computational Fluid Dy	namics II			
Courses					
Title			Тур	Hrs/wk	СР
Computational Fluid Dyna	mics II (L0237)		Lecture	2	3
Computational Fluid Dyna	mics II (L0421)		Recitation Section (large)	2	3
Module Responsible	Prof. Thomas Rung				
Admission Requirements	None				
Recommended Previous Knowledge	Rasics of computational and de	eneral thermo/fl	uid dynamics		
Educational Objectives	After taking part successfully s	tudents have re	ached the following lea	rning resul	ts
Professional Competence					
Knowledge	Establish a thorough understanding of Finite-Volume approaches. Familiarise with details of the theoretical background of complex CFD algorithms.				with details of
Skills	assess and benchmark differen	Ability to manage of interface problems and build-up of coding skills. Ability to evaluat assess and benchmark different solution options.			to evaluate
Personal Competence					
Social Competence	Practice of team working during	g team exercise	S.		
Autonomy	Indenpendent analysis of spec	ific solution app	oroaches.		
Workload in Hours	Independent Study Time 124, S	Study Time in Le	ecture 56		
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and scale	10 5n-0 /5n				
Assignment for the Following Curricula		Engineering: Co eering: Technica eering: Core qua	ore qualification: Electiv al Complementary Cour alification: Elective Com	se: Elective	

Course L0237: Compu	Itational 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: Compu	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						
Title Optimal and Robust Control (L0658)			Typ Lecture		Hrs/wk 2	СР 3
Optimal and Robust Contr Optimal and Robust Contr			Recitation Section			3
Module Responsible	Prof. H	lerbert Werner				
Admission Requirements	None					
Recommended Previous Knowledge	•	Classical control (frequer State space methods Linear algebra, singular v				
Educational Objectives	After ta	aking part successfully, stu	dents have reached the followi	ng lear	ning resul	ts
Professional Competence						
Knowledge	• • •	 performance constraints. They can explain how an LQG design problem can be formulated as special of an H2 design problem. 				optimal st nt stability a pecial case nat lends its controller o
Skills	 Students are capable of designing and tuning LQG controllers for multivariable models. They are capable of representing a H2 or H-infinity design problem in the forr generalized plant, and of using standard software tools for solving it. They are capable of translating time and frequency domain specifications for cloops into constraints on closed-loop sensitivity functions, and of carrying out a r sensitivity design. They are capable of constructing an LFT uncertainty model for an uncertain sy and of designing a mixed-objective robust controller. They are capable of formulating analysis and synthesis conditions as linear inequalities (LMI), and of using standard LMI-solvers for solving them. They can carry out all of the above using standard software tools (Matlab robust ot toolbox). 					the form cons for con g out a mixe ertain syste linear ma
Personal Competence						
Social Competence			os on specific problems to arriv	-		
Autonomy		-	ed information in sources pro e it to solve given problems.	vided (lecture no	tes, literatu

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	
Examination duration and scale	30 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory



Course L0658: Optima	I and 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 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			

Module M0605: C	computational Structural Dy	/namics			
Courses					
Title		Тур	Hrs/wk	СР	
Computational Structural I		Lecture	3	4	
Computational Structural I	Dynamics (L0283)	Recitation Section (small) 1	2	
Module Responsible	Prof. Alexander Düster				
Admission Requirements	None				
Recommended Previous Knowledge	Knowledge of partial differential equa	ations is recommended.			
Educational Objectives	After taking part successfully, student	s have reached the followir	ng learning resul	lts	
Professional					
Competence					
Knowledge	Students are able to + give an overview of the computational procedures for problems of structural dynamics. + explain the application of finite element programs to solve problems of structural dynamics. + specify problems of computational structural dynamics, to identify them in a given situation and to explain their mathematical and mechanical background.				
Skills	Students are able to + model problems of structural dynamics. + select a suitable solution procedure for a given problem of structural dynamics. + apply computational procedures to solve problems of structural dynamics. + verify and critically judge results of computational structural dynamics.				
Personal					
Competence	Otoda ata ang akla ta				
Social Competence	Students are able to + solve problems in heterogeneous g	roups and to document the	corresponding	results.	
Autonomy	Students are able to + acquire independently knowledge				
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 56			
Credit points					
Course achievement					
Examination	Written exam				
Examination duration and scale					
Assignment for the Following Curricula	International Management and E Compulsory Materials Science: Specialisation Mo Mechatronics: Technical Complemen Naval Architecture and Ocean Engine Theoretical Mechanical Engineering: Theoretical Mechanical Engineering:	deling: Elective Compulsor ntary Course: Elective Comp eering: Core qualification: E Technical Complementary	y oulsory Elective Compuls Course: Elective	sory	

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

Course 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			

analysis	Desi	gn optimization and prob		nes m	Structure	
Courses						
Title Design Optimization and I (L1873)		stic Approaches in Structural Analysis stic Approaches in Structural Analysis	Typ Lecture Recitation Section (large)	Hrs/wk 2 2	СР 3 3	
Module Responsible	Prof. B	enedikt Kriegesmann				
Admission Requirements	None					
Recommended Previous Knowledge		Technical mechanics Higher math				
Educational Objectives	Δttor to	king part successfully, students have	reached the following lea	Irning resu	Its	
Professional Competence						
Knowledge	, •	 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 	on and reliability analysis	5		
Skills		Application of optimization algorith structures Programming with Matlab Implementation of algorithms Debugging	ms and probabilistic me	ethods in	the design	
Personal Competence						
Social Competence	•	Team work Oral explanation of the the work				
Autonomy	•	 Application of methods learned in the framework of a home work Familiarizing with source code provided Description of approaches and results 				
Workload in Hours	Indepe	endent Study Time 124, Study Time in	Lecture 56			
Credit points	6					
Course achievement	None					
Examination	Writter	elaboration				

Course L1873: Design	Optimization and Probabilistic Approaches in Structural Analysis
Тур	Lecture
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	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 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				
Content	Matlab exercises complementing the lecture			
Literature	siehe Vorlesung			

Courses							
Title				Тур	Hrs/wk	СР	
High-Order FEM (L0280) High-Order FEM (L0281)				Lecture Recitation Section (large)	3	4 2	
Module Responsible							
Admission Requirements							
Recommended Previous Knowledge	Knowledge c	of partial diff	ferential equations	is recommended.			
Educational Objectives	After taking p	art success	sfully, students hav	e reached the following lea	arning resu	lts	
Professional Competence							
Knowledge	Students are able to + give an overview of the different (h, p, hp) finite element procedures. + explain high-order finite element procedures. + specify problems of finite element procedures, to identify them in a given situation and to explain their mathematical and mechanical background.						
Skills	Students are able to + apply high-order finite elements to problems of structural mechanics. + select for a given problem of structural mechanics a suitable finite element procedure. + critically judge results of high-order finite elements. + transfer their knowledge of high-order finite elements to new problems.						
Personal Competence							
Social Competence	Students are able to + solve problems in heterogeneous groups and to document the corresponding results.						
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks.						
Workload in Hours	Independent	Study Time	e 124, Study Time i	n Lecture 56			
Credit points	6						
Course achievement	Compulsory BonusFormDescriptionNo10 %PresentationForschendes Lernen						
Examination	Written exam						
Examination duration and scale	120 min						
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory						

Course L0280: High-O	Course L0280: High-Order FEM				
Тур	Lecture				
Hrs/wk	3				
СР	4				
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42				
Lecturer	Prof. Alexander Düster				
Language	EN				
Cycle	SoSe				
Content	 Introduction Motivation Hierarchic shape functions Mapping functions Computation of element matrices, assembly, constraint enforcement and solution Convergence characteristics Mechanical models and finite elements for thin-walled structures Computation of thin-walled structures Error estimation and hp-adaptivity 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-O	Course 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				

Module M0603: N	Ionlinear Structural Analy	sis		
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Structural Analy Nonlinear Structural Analy		Lecture Recitation Section (small	3	4 2
	Prof. Alexander Düster		, .	-
Admission				
Requirements				
Recommended Previous Knowledge	Knowledge of partial differential eq	uations is recommended.		
Educational Objectives	After taking part successfully, stude	nts have reached the following lea	arning resu	lts
Professional Competence				
Knowledge	Students are able to + give an overview of the different nonlinear phenomena in structural mechanics.			
Skills	 Students are able to + model nonlinear structural problems. + select for a given nonlinear structural problem a suitable computational procedure. + apply finite element procedures for nonlinear structural analysis. + critically verify and judge results of nonlinear finite elements. + to transfer their knowledge of nonlinear solution procedures to new problems. 			
Personal Competence				
Social Competence	Students are able to + solve problems in heterogeneous groups and to document the corresponding results. + share new knowledge with group members.			
Autonomy	Students are able to + acquire independently knowledge to solve complex problems.			
Workload in Hours	I Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	120 min			
-	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Ship and Offshore Technology: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

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Course L0277: Nonlinear Structural 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	 Introduction Nonlinear phenomena Mathematical preliminaries Basic equations of continuum mechanics Spatial discretization with finite elements Solution of nonlinear systems of equations Solution of elastoplastic problems Stability problems 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: Nonline	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 M0832: A	Advanced Topics in Control	I		
Courses				
Title Advanced Topics in Cont Advanced Topics in Cont		Typ Lecture Recitation Section (Hrs/wk 2 (small) 2	CP 3 3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	H-Infinity optimal control, mixed-sens	sitivity design, linear matrix i	inequalities	
Educational Objectives	After taking part successfully, student	ts have reached the followin	ng learning resu	Its
Professional Competence				
Knowledge	 Students can explain the advantages and shortcomings of the classical gain scheduling approach They can explain the representation of nonlinear systems in the form of quasi-LPV systems They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures 			
	 Students are capable of consmixed-sensitivity design of polytopic, LFT or general LPV They are able to use standar tasks 	gain-scheduled controlle / models	rs; they can	do this using
Skills	 Students are able to design of either LTI or LPV dynamics, u 		llers for groups	of agents with
	 Students are able to design d using the Matlab MD-toolbox 	listributed controllers for spa	atially interconn	ected systems

Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Anagement and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Anagement and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0661: Advanced Topics 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 Control of Spatially Interconnected Systems Multidimensional signals, I2 and L2 signal norm Multidimensional systems in Roesser state space form Extension of real-bounded lemma to spatially interconnected systems LMI-based synthesis of distributed controllers Spatial LPV control of spatially varying systems Applications: control of temperature profiles, vibration damping for an actuated beam 	
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

	Research Project Theoretical Mechanical Engineering	
Courses		
Title	Typ Hrs/wk CP	
Module Responsible		
Admission Requirements	None	
Recommended Previous Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional		
Competence	The students are able to demonstrate their detailed knowledge in the field of theoretica	
	mechanical engineering. They can exemplify the state of technology and application an discuss critically in the context of actual problems and general conditions of science an society.	
Knowledge	The students can develop solving strategies and approaches for fundamental and practica problems in theoretical mechanical engineering. They may apply theory based procedure and integrate safety-related, ecological, ethical, and economic view points of science an 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 th choice. They can explain how these methods relate to the field of work and how the context application has to be adjusted. General findings and further developments may essentially b outlined.	
Personal Competence		
Social Competence	The students are able to condense the relevance and the structure of the project work, th work steps and the sub-problems for the presentation and discussion in front of a bigge group. They can lead the discussion and give a feedback on the project to their colleagues.	
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.	
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0	
Credit points		
Course achievement		
Examination		
Examination duration and scale	according to FSPO	
Assignment for the Following Curricula	Theoretical Mechanical Engineering: Core qualification: Compulsory	



	Selected Topics in Multibody Dynamics and Robotics			
Courses				
TitleTypHrs/wkCPFormulas and Vehicles - Mathematics and Mechanics in Autonomous DrivingProject-/problem-based Learning26				
Module Responsible				
Admission Requirements	None			
	Mechanics IV, Applied Dynamics or Robotics			
Recommended Previous Knowledge	Numerical Treatment of Ordinary Differential Equations			
C C	Control Systems Theory and Design			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional				
Competence Knowledge	After successful completion of the module students demonstrate deeper knowledge and understanding in selected application areas of multibody dynamics and robotics			
	Students are able			
	+ to think holistically			
Skills	+ to independently, securly and critically analyze and optimize basic problems of th dynamics of rigid and flexible multibody systems			
	+ to describe dynamics problems mathematically			
	+ to implement dynamical problems on hardware			
Personal Competence				
oompetenee	Students are able to			
Social Competence	+ solve problems in heterogeneous groups and to document the corresponding results and present them			
	Students are able to			
Autonomy	+ assess their knowledge by means of exercises and projects.			
	+ acquaint themselves with the necessary knowledge to solve research oriented tasks.			
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28			
Credit points	6			
Course achievement	None			
	Presentation			
Examination duration and scale	ТВА			
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory			

Course L1981: Formulas and Vehicles - Mathematics and Mechanics in Autonomous Driving		
Тур	Typ 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	
Language	DE	
Cycle	WiSe	
Content		
Literature	Seifried, R.: Dynamics of underactuated multibody systems, Springer, 2014 Popp, K.; Schiehlen, W.: Ground vehicle dynamics, Springer, 2010	

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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: A	pplied Statistics			
Courses				
Title	Т	Гур	Hrs/wk	СР
Applied Statistics (L1584)			2	3
Applied Statistics (L1586)		Project-/problem-based Learning	2	2
Applied Statistics (L1585)	F	Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of statistical methods			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	Students can explain the statistical methods and the conditions of their use.			
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results			
Personal Competence				
Social Competence	Team Work, joined presentation of results			
Autonomy	To understand and interpret the question and solve			
Workload in Hours	Independent Study Time 110, Study Time in Leo	cture 70		
Credit points	6			
Course achievement	Compulsory BonusFormDescriptionYesNoneWritten elaboration			
Examination	Written exam			
Examination duration and scale	90 minutes, 28 questions			
-	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Core qualification: Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L1584: Applied Statistics		
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/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	d Statistics
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
Content	The students receive a problem task, which they have to solve in small groups (n=5). They do have to collect their own data and work with them. The results have to be presented in an executive summary at the end of the course.
Literature	Selbst zu finden

Course L1585: Applied	Statistics
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
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



Module M1334: E	IO II: Biomaterials				
Courses					
Title Biomaterials (L0593)		Typ Lecture	Hrs/wk 2	СР 3	
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgic	al techniques is rec	commended.		
Educational Objectives	After taking part successfully, students hav	ve reached the follo	wing learning resu	lts	
Professional Competence					
Knowledge	The students can describe the materials medical engineering, and their fields of us		and the materials	being used	
Skills	The students can explain the advantages	and disadvantages	of different kinds o	f biomateria	
Personal Competence					
Social Competence	The students are able to discuss issues r replacements with student mates and the		being present or b	being used	
Autonomy	The students are able to acquire information with respect to its credibility.	on on their own. Th	ey can also judge t	he information	
Workload in Hours	Independent Study Time 62, Study Time ir	n Lecture 28			
Credit points	3				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	90 min				
Assignment for the Following Curricula	TRIOMATICAL Engineering' Specialisation Medical Technology and Control Theory' Elective				

Course L0593: Biomaterials			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		

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

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



Madula M1200. A	nulied Humanaid D	chatica			
Module M1302: A	pplied Humanoid R	ODOTICS			
Courses					
Title			Тур	Hrs/wk	СР
Applied Humanoid Robotic	s (L1794)		Project-/problem-based Learning	6	6
Module Responsible	Patrick Göttsch				
Admission Requirements	None				
Recommended Previous Knowledge	 Object oriented prog Introduction to control Control systems the Mechanics 	ol systems	ms and data structures		
Educational Objectives	After taking part successfull	y, students have re	eached the following lea	Irning resul	lts
Professional Competence					
Knowledge	inverse kinematics	in the basic conce	s. epts, relationships and t oncepts for different tasl		
Skills	 Students can implement models for humanoid robotic systems in Matlab and C++, and use these models for robot motion or other tasks. They are capable of using models in Matlab for simulation and testing these models if necessary with C++ code on the real robot system. They are capable of selecting methods for solving abstract problems, for which no standard methods are available, and apply it successfully. 				
Personal Competence					
Social Competence			n mixed teams and presect to others, and constr		ndle feedbac
Autonomy	 Students are able to obtain required information from provided literature sources, and to put in into the context of the lecture. They can independently define tasks and apply the appropriate means to solve them. 				
Workload in Hours	Independent Study Time 96	, Study Time in Le	cture 84		
Credit points	6				
Course achievement	None				
Examination	Written elaboration				
Examination duration and scale	5-10 pages				
Assignment for the Following Curricula	Computer Science: Special Mechatronics: Specialisatio Theoretical Mechanical En Compulsory Theoretical Mechanical Eng	n Intelligent Syste gineering: Specia	ms and Robotics: Electiv Ilisation Bio- and Medio	ve Compuls cal Techno	sory logy: Elective

Course L1794: Applied	d 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)



Medical Imaging Systems (L0819) Module Responsible Dr. Michael Grass Admission Requirements None Recommended Previous Knowledge none Educational Objectives After taking part successfully, students Professional Competence Students can: Explain how the system configue systems; Explain how the system configue systems; Knowledge Students can: Knowledge Students are and explain how the system configue systems; Explain how spatial and the characterize the images gene Explain how spatial and the characterize the images gene Explain which image reconstru- Describe and explain the main clinical students are able to: Explain the physical process mathematical or physical equations; Skills Determine the influen- temporal resolution of one Explain the physical equations;	uration and components conents and the overall I processes that make in ns; cal effects required to gen emporal resolution car rated; uction methods are used I uses of the different sys ses of images and as ations required;	s of the main cli system of the ima naging possible an nerate image contr n be influenced I to generate image stems.	nical imagir aging system ad use with th rasts; and how es;
Admission Requirements None Recommended Previous Knowledge none Educational Objectives After taking part successfully, students Professional Competence Students can: Bescribe the system configue systems; • Describe the system configue systems; Explain how the system comp function; • Explain how the system comp function; Knowledge • Describe the system comp function; Knowledge • Describe the system comp function; Explain how the system comp function; • Explain and apply the physical fundamental physical equation • Name and describe the physical fundamental physical equation • Name and describe the physical fundamental physical equation • Explain which image reconstrue Describe and explain the main clinical Students are able to: • Explain the physical proces mathematical or physical equations; • Calculate the paramo physical equations; • Determine the influent temporal resolution of • Explain the importance	uration and components conents and the overall I processes that make in ns; cal effects required to gen emporal resolution car rated; uction methods are used I uses of the different sys ses of images and as ations required;	s of the main cli system of the ima naging possible an nerate image contr n be influenced I to generate image stems.	nical imagir aging system ad use with th rasts; and how es;
RequirementsNoneRecommended Previous KnowledgenoneEducational ObjectivesAfter taking part successfully, studentsProfessional CompetenceStudents can:Professional CompetenceStudents can:KnowledgeStudents can:KnowledgeDescribe the system configure systems;KnowledgeStudents can:KnowledgeStudents can:KnowledgeStudents can:KnowledgeStudents can:KnowledgeStudents can:KnowledgeStudents can:KnowledgeStudents can:KnowledgeStudents can:KnowledgeStudents and apply the physical characterize the images gene e Explain how spatial and to characterize the images gene e Explain which image reconstruct Describe and explain the main clinical explain which image reconstruct explain which image reconstruct explain the physical process mathematical or physical equations; e Calculate the paramous physical equations; e Determine the influent temporal resolution of e Explain the importance	uration and components conents and the overall I processes that make in ns; cal effects required to gen emporal resolution car rated; uction methods are used I uses of the different sys ses of images and as ations required;	s of the main cli system of the ima naging possible an nerate image contr n be influenced I to generate image stems.	nical imagir aging systen nd use with th rasts; and how es;
Previous KnowledgenoneEducational ObjectivesAfter taking part successfully, studentsProfessional CompetenceStudents can:ObjectivesStudents can:• Describe the system configu systems;• Describe the system configu systems;• Explain how the system configu systems;• Explain how the system configu systems;• Explain and apply the physical function;• Explain and apply the physical fundamental physical equation • Name and describe the physica Explain how spatial and the characterize the images gene • Explain which image reconstruct Describe and explain the main clinical • Calculate the parame physical equations;Skills• Explain the physical proces mathematical or physical equations; • Determine the influent temporal resolution of • Explain the importance	uration and components conents and the overall I processes that make in ns; cal effects required to gen emporal resolution car rated; uction methods are used I uses of the different sys ses of images and as ations required;	s of the main cli system of the ima naging possible an nerate image contr n be influenced I to generate image stems.	nical imagir aging systen nd use with th rasts; and how es;
ObjectivesAfter taking part successfully, studentsProfessional CompetenceStudents can:Describe the system configu systems;Describe the system configu systems;Explain how the system comp function;KnowledgeKnowledgeExplain and apply the physical fundamental physical equationName and describe the physical fundamental physical equationName and describe the physical fundamental physical equationExplain how spatial and the characterize the images geneExplain which image reconstrueDescribe and explain the main clinical Students are able to:Explain the physical process mathematical or physical equations;Calculate the parame physical equations;Determine the influen temporal resolution of oExplain the importance	uration and components conents and the overall I processes that make in ns; cal effects required to gen emporal resolution car rated; uction methods are used I uses of the different sys ses of images and as ations required;	s of the main cli system of the ima naging possible an nerate image contr n be influenced I to generate image stems.	nical imagir aging systen nd use with th rasts; and how es;
CompetenceStudents can:• Describe the system configure systems;• Explain how the system compliance function;• Explain how the system compliance function;• Explain and apply the physical fundamental physical equation • Name and describe the physical • Explain how spatial and the characterize the images gene • Explain which image reconstruct Describe and explain the main clinical Students are able to:SkillsSkillsSkillsSkillsSkillsSkillsSkills	oonents and the overall I processes that make in ns; cal effects required to gen emporal resolution can rated; uction methods are used I uses of the different sys ses of images and as ations required;	system of the ima naging possible an nerate image contr n be influenced I to generate image stems. sign to the syste	aging system ad use with th rasts; and how es;
 Describe the system configure systems; Explain how the system compliance of the physical explain how the system compliance of the physical equation. Explain and apply the physical equation. Name and describe the physical equation. Name and describe the physical explain how spatial and the characterize the images gene. Explain which image reconstruct the physical explain which image reconstruct the physical explain the main clinical students are able to: Explain the physical process mathematical or physical equations; Calculate the parameter of the physical equations; Determine the influent temporal resolution of the physical explain the importance of the physical explain the physical explain the physical explain the physical explain explain the physical explain explain the physical expla	oonents and the overall I processes that make in ns; cal effects required to gen emporal resolution can rated; uction methods are used I uses of the different sys ses of images and as ations required;	system of the ima naging possible an nerate image contr n be influenced I to generate image stems. sign to the syste	aging system ad use with th rasts; and how es;
 mathematical or physical equal Calculate the parametry physical equations; Skills Determine the influen temporal resolution of Explain the importance 	ations required;		ms the bas
	ce of different system o imaging systems; e of different imaging s	components on th	ie spatial a
Select a suitable imaging system for a	In application.		
Personal Competence			
Social Competence none			
Students can:			
 Autonomy Understand which physical eff Decide independently for which 			e used.
Workload in Hours Independent Study Time 124, Study T	ime in Lecture 56		
Credit points 6			
Course achievement None			

and scale	
Assignment for the Following Curricula	COMPUTEOR/

Course L0819: Medica	I Imaging Systems
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.



Module M1335: E	BIO II: Artificial Joint Re	placement		
Courses				
Title Artificial Joint Replacemen	nt (L1306)	Typ Lecture	Hrs/wk 2	СР 3
	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic	and surgical techniques is recor	mmended.	
Educational Objectives	After taking part successfully, s	tudents have reached the followi	ng learning resu	lts
Professional Competence				
Knowledge	The students can name the dif	ferent kinds of artificial limbs.		
Skills	The students can explain endoprotheses.	the advantages and disadvar	ntages of differ	ent kinds of
Personal Competence				
Social Competence		uss issues related to endoprothe	se with student i	mates and the
Autonomy	The students are able to acqui with respect to its credibility.	re information on their own. They	can also judge t	he information
Workload in Hours	Independent Study Time 62, S	tudy Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Orientierungsstudium: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			



ourse L1306: Artificia	al 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	
Cycle	
	Inhalt (deutsch)
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker satzes)
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportlich Aktivität)
	3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite Evolution der Implantate)
Content	4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibial und patelläre Komponenten)
	5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren)
	6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz)
	7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
	8. DIE HAND (Anatomie, Biomechanik, Ge-lenkersatz)
	9. TRIBOLOGIE NATÜRLICHER UND KÜNST-LICHER GELENKE (Korrosion, Reibung Verschleiß)
	Literatur:
	Kapandji, I: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.
Literature	Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994
	Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febige Philadelphia, 1989.
	Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.
	Sobotta und Netter für Anatomie der Gelenke

Module M0630: R	lobotics and Na	avigation in Mec	licine		
Courses					
Title			Тур	Hrs/wk	СР
Robotics and Navigation in			Lecture Project Seminar	2 2	3 2
Robotics and Navigation in Robotics and Navigation in			Project Seminar Recitation Section (small)		2
Module Responsible		laefer		-	-
A dmission					
Recommended Previous Knowledge		math (algebra, analys programming, e.g., in atlab skills			
Educational Objectives	After taking part suc	cessfully, students hav	ve reached the following lea	rning resu	lts
Professional Competence					
Competence		valain kinomatiaa and	tracking overems in clinics	al contoxto	and illustra
Knowledge	The students can explain kinematics and tracking systems in clinical contexts and illustra systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations.				
Skills	medical applications	-	aluate navigation systems	and robot	ic systems
Personal Competence	The students disc	use the results of a	ther groups, provide help	aful foodb	ack and a
Social Competence	incoorporate feedba		niner groups, provide neit	Jui leedb	ack and c
Autonomy		eflect their knowledge n an appropriate manr	and document the results ner.	of their w	ork. They c
Workload in Hours	Independent Study	Time 110, Study Time	in Lecture 70		
Credit points	6				
Course achievement	Compulsory BonusYes10 %Yes10 %	Form Written elabora Presentation	Descriptio ation	n	
Examination	Written exam				
Examination duration and scale					
	Electrical Engineerin International Manag Compulsory Mechatronics: Speci Biomedical Enginee Compulsory Biomedical Enginee	ng: Specialisation Med ement and Engineeri alisation Intelligent Sy pring: Specialisation A pring: Specialisation In	ence Engineering: Elective C dical Technology: Elective C ng: Specialisation II. Electric vstems and Robotics: Electiv rtificial Organs and Regene nplants and Endoprostheses Medical Technology and C	ompulsory cal Engine re Compul rative Med s: Elective	, ering: Electi sory licine: Electi Compulsory

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

Course L0335: Robotics and Navigation in Medicine			
Тур	Lecture		
Hrs/wk	2		
СР	3		
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 Navigation in Medicine		
Project Seminar		
2		
2		
Independent Study Time 32, Study Time in Lecture 28		
Prof. Alexander Schlaefer		
EN		
SoSe		
See interlocking course		
See interlocking course		

Course L0336: Robotic	Course 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		

Modulo M0549, P	Dio al o atra ma su a tias		d Applications		
-	Bioelectromagnetics	S. Philiciples an			
Courses			T		
Title Bioelectromagnetics: Princ	ciples and Applications (L0371)	Typ Lecture	Hrs/wk 3	CP 5
-	ciples and Applications (L0373		Recitation Section (small)	2	1
Module Responsible	Prof. Christian Schuster				
Admission Requirements	None				
Recommended Previous Knowledge		3			
Educational Objectives	After taking part successfu	lly, students have re	ached the following lea	rning resul	ts
Professional					
Competence					
Knowledge	Students can explain the to i.e. the quantification and define and exemplify the r to wavelength and frequen numerical techniques for They can give examples f medical technology.	application of elect most important phys ncy of the fields. The characterization of e	romagnetic fields in bic ical phenomena and or ey can give an overview electromagnetic fields in	ological tiss rder them c v over meas n practical	ue. They can orresponding surement and applications
Skills	Students know how to app fields in biological tissue. solutions of Maxwell's Equ models predict for biologi and frequency, respectivel develop validation strateg electromagnetic fields for choice.	In order to do this th uations. They are abl cal tissue, they can ly, and they can ana gies for their predic	ey can relate to and ma le to assess the most im order the effects corre lyze them in a quantitati tions. They are able to	ke use of the portant effe sponding t ive way. The o evaluate	ne elementar ects that these o wavelengt ey are able to the effects of
Personal					
Competence		to pollo a ser a la la la	alatad table (
Social Competence	Students are able to work present their results effecti				ey are able to
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English.				
Workload in Hours	Independent Study Time 1	10, Study Time in Le	ecture 70		
Credit points					
Course achievement	Compulsory Bonus	Form Presentation	Descriptio	on	



Examination	Oral exam
Examination duration and scale	143 (0)0
Assignment for the Following Curricula	I BIOMAGICAL ENGINAARING' SNACIAILEATION IMPLANTE AND ENGONOCTNACAE' ELACTIVA L'OMPLILEON/

Tun	Lecture
Hrs/wk	
CP	
	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
	- 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
Content	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CF
	(2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wil (2006)
Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagne Fields", CRC (2006)

Course L0373: Bioeled	Course 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	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

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Hamburg University of Technolog

Module M1182: T Regulations)	Fechnical Elective Course for TMBMS (according to Subject Spe	cific
Courses		
Title	Typ Hrs/wk CP	
Module Responsible	Prof. Robert Seifried	
Admission Requirements	None	
Recommended Previous Knowledge	ISEE ESP()	
Educational Objectives	Atter taking part successfully, students have reached the following learning results	
Professional Competence Knowledge	see FSPO	
Skills Personal Competence		
Social Competence Autonomy	see FSPO see FSPO	
Workload in Hours	Depends on choice of courses	
Credit points	6	
Assignment for the Following Curricula		lective Isory lective ory cience

TUHH Hamburg University of Technology

Module M1249: N	lumerical Methods for Me	dical Imaging		
Courses				
Title Numerical Methods for Me Numerical Methods for Me		Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. Tobias Knopp			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stud	ents have reached the following lea	rning result	IS
Professional Competence				
Knowledge Skills				
Personal Competence				
Social Competence Autonomy				
Workload in Hours	Independent Study Time 124, Stud	dy Time in Lecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	90 min			
	Electrical Engineering: Specialisa Electrical Engineering: Specialisa Computational Science and Engin Elective Compulsory Theoretical Mechanical Engineer Compulsory	Intelligence Engineering: Elective C tion Medical Technology: Elective C tion Modeling and Simulation: Elect neering: Specialisation Systems En ing: Specialisation Bio- and Medic ng: Technical Complementary Cour	ompulsory ive Compul gineering a cal Technol	sory and Robotics logy: Elective

Course L1694: Numer	ical Methods for Medical Imaging
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Tobias Knopp
Language	DE
Cycle	WiSe
Content	
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

Course L1695: Numer	ourse L1695: Numerical Methods for 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		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0921: Electronic Circuits for Medical Applications

Courses				
Title	Тур	Hrs/wk	СР	
Electronic Circuits for Medical Applications (L0696)	Lecture	2	3	
Electronic Circuits for Medical Applications (L1056)	Recitation Section (small)	1	2	
Electronic Circuits for Medical Applications (L1408)	Practical Course	1	1	

Module Responsible	
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of electrical engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	 Students can explain the basic functionality of the information transfer by the central nervous system Students are able to explain the build-up of an action potential and its propagation along an axon Students can exemplify the communication between neurons and electronic devices Students can describe the special features of low-noise amplifiers for medical applications Students can explain the functions of prostheses, e. g. an artificial hand Students are able to discuss the potential and limitations of cochlea implants and artificial eyes
Skills	 Students can calculate the time dependent voltage behavior of an action potential Students can give scenarios for further improvement of low-noise and low-power signal acquisition. Students can develop the block diagrams of prosthetic systems Students can define the building blocks of electronic systems for an articifial eye.
Personal Competence Social Competence	 Students are trained to solve problems in the field of medical electronics in teams together with experts with different professional background. Students are able to recognize their specific limitations, so that they can ask for assistance to the right time.
Autonomy	 Students are able to realistically judge the status of their knowledge and to define actions for improvements when necessary. Students can break down their work in appropriate work packages and schedule their work in a realistic way. Students can handle the complex data structures of bioelectrical experiments without needing support.



	 Students are able experimental work 	e to act in a responsible manner in all cases and situations of
Workload in Hours	Independent Study Time 1	24, Study Time in Lecture 56
Credit points	6	
	Compulsory Bonus	Form Description
Course achievement	Yes None	Subject theoretical and practical work
	No None	Excercises
Examination	Written exam	
Examination duration and scale	90 min	
Assignment for the Following Curricula	Biomedical Engineering: S Compulsory Biomedical Engineering: S Biomedical Engineering: S Biomedical Engineering: Compulsory Microelectronics and Mic Compulsory Theoretical Mechanical E Compulsory	ecialisation Medical Technology: Elective Compulsory Specialisation Artificial Organs and Regenerative Medicine: Elective Specialisation Implants and Endoprostheses: Elective Compulsory Specialisation Medical Technology and Control Theory: Compulsory Specialisation Management and Business Administration: Elective rosystems: Specialisation Microelectronics Complements: Elective Engineering: Specialisation Bio- and Medical Technology: Elective

Course L0696: Electro	nic Circuits 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: Electro	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: Electro	nic Circuits 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 M0746: N					
-					
Courses					
Title Microsystem Engineering	(L0680)		Typ Lecture	Hrs/wk 2	CP 4
Microsystem Engineering	(L0682)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper				
Admission Requirements	Nono				
Recommended Previous Knowledge		, mathematics and e	lectric engineering		
Educational Objectives	Attor taking part cuccocc	fully, students have r	reached the following lea	arning resul	ts
Professional Competence					
Knowledge	The students know about their applications in sense		t technologies and mate	rials of ME	MS as well
Skills	Students are able to ana to evaluate the potential		e functional behaviour o	f MEMS co	mponents a
Personal Competence					
Social Competence	Students are able to so	lve specific problem	s alone or in a group a	nd to prese	ent the resu
	Students are able to so	uire particular know	ledge using specialized		
Autonomy	Students are able to so accordingly. Students are able to acc	uire particular know ledge with other field	ledge using specialized s.		
Autonomy	Students are able to so accordingly. Students are able to acc and associate this know Independent Study Time	uire particular know ledge with other field	ledge using specialized s.		
Autonomy Workload in Hours	Students are able to so accordingly. Students are able to acc and associate this know Independent Study Time 6 Compulsory Bonus	uire particular know ledge with other field	ledge using specialized s.	literature a	
Autonomy Workload in Hours Credit points Course achievement	Students are able to so accordingly. Students are able to acc and associate this know Independent Study Time 6 Compulsory Bonus	uire particular know ledge with other field a 124, Study Time in Form	ledge using specialized ls. Lecture 56	literature a	
Autonomy Workload in Hours Credit points Course achievement	Students are able to so accordingly. Students are able to acc and associate this know Independent Study Time 6 Compulsory Bonus No 10 % Written exam 2h	uire particular know ledge with other field a 124, Study Time in Form Presentation	ledge using specialized ls. Lecture 56 Descriptic	literature a	
Autonomy Workload in Hours Credit points Course achievement Examination Examination duration	Students are able to so accordingly. Students are able to acc and associate this know Independent Study Time 6 Compulsory Bonus No 10 % Written exam 2h Electrical Engineering: C Computational Science Elective Compulsory International Managem Compulsory International Managem Compulsory International Engineering Mechanical Engineering	uire particular know ledge with other field a 124, Study Time in Form Presentation Core qualification: Co and Engineering: Sp ent and Engineering: Sp ent and Engineering: and Management: Sp ation System Design : Specialisation Artifi : Specialisation Impla : Specialisation Me	Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Description Descri	ngineering cal Engineering ics: Elective erative Med s: Elective (Control Th	and Robotion and Robotion ering: Election nics: Election e Compulsory eory: Election



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

Course L0680: Micros	ystem Engineering
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Manfred Kasper
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
Literature	Yield, test and reliability M. Kasper: Mikrosystementwurf, Springer (2000) M. Madou: Fundamentals of Microfabrication, CRC Press (1997)

Course L0682: Micros	urse 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	Prof. Manfred Kasper		
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 Intelligent Systems in Medicine (L0331)				Typ Lecture	Hrs/wk 2	СР 3
Intelligent Systems in Medicine (L0334)				Project Seminar	2	2
Intelligent Systems in Med	. ,			Recitation Section (small) 1	1
Module Responsible	Prof. Alexander S	Schlaefer				
Admission Requirements	None					
Recommended Previous Knowledge						
Educational Objectives	After taking part s	successfully	, students have r	eached the following lea	arning resu	lts
Professional Competence						
Knowledge	The students are able to analyze and solve clinical treatment planning and decision suppor problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.					
Skills	The students can give reasons for selecting and adapting methods for classificatior regression, and prediction. They can assess the methods based on actual patient data an evaluate the implemented methods.					
Personal Competence						
Social Competence				r groups, provide hel	pful feedb	ack and ca
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.					
Workload in Hours	Independent Stud	dy Time 110), Study Time in L	ecture 70		
Credit points	6					
O annual a state of the	Compulsory Bor		orm //ittensistensisten	Descriptio	on	
Course achievement	Yes 10 ^o Yes 10 ^o		Iritten elaboration	1		
F uce with a stick in		% P	resentation			
Examination Examination duration	Written exam					
and scale	90 minutes					
		•	ialisation Medica	e Engineering: Elective Il Technology: Elective (Compulsory	1
	Computational S Elective Compuls Mechatronics: Sp	sory pecialisation	Intelligent Syste	ms and Robotics: Electi cial Organs and Regene	ve Compul	sory

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

Course L0331: Intellige	ent Systems 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 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 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	

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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 M0742: T	hermal Engineering			
Courses				
Title		Тур	Hrs/wk	СР
Thermal Engineering (L00	•	Lecture	3	5
Thermal Engineering (L00	24)	Recitation Section (large)	1	1
Module Responsible	Prof. Gerhard Schmitz			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dy	ynamics, Heat Transfer		
Educational Objectives	After taking part successfully, students h	ave reached the following lea	rning resu	lts
Professional Competence				
Knowledge	Students know the different energy conversion stages and the difference between efficiency and annual efficiency. They have increased knowledge in heat and mass transfer, especially in regard to buildings and mobile applications. They are familiar with German energy saving code and other technical relevant rules. They know to differ different heating systems in the domestic and industrial area and how to control such heating systems. They are able to model a furnace and to calculate the transient temperatures in a furnace. They have the basic knowledge of emission formations in the flames of small burners and how to conduct the flue gases into the atmosphere. They are able to model thermodynamic systems with object oriented languages.			
Skills	Students are able to calculate the heating demand for different heating systems and to choose the suitable components. They are able to calculate a pipeline network and have the ability to perform simple planning tasks, regarding solar energy. They can write Modelica programs and can transfer research knowledge into practice. They are able to perform scientific work in the field of thermal engineering.			
Personal Competence				
Social Competence	The students are able to discuss in smal	ll groups and develop an appr	roach.	
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.			
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points	6			
Course achievement	None			

Examination	Written exam
Examination duration and scale	60 min
Assignment for the Following Curricula	International Manadement and Endineering. Specialisation II. Energy and Environmental

Course L0023: Thermal Engineering			
Тур	Lecture		
Hrs/wk	;		
СР	5		
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42		
Lecturer	Prof. Gerhard Schmitz		
Language	DE		
Cycle	WiSe		
Content	 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 Engineering		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Gerhard Schmitz	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1235: E	lectrical Power Systems I: Introdu	uction to Electrica	al Power	Systems
Courses				
	I: Introduction to Electrical Power Systems (L1670) I: Introduction to Electrical Power Systems (L1671)		Hrs/wk 3 2	CP 4 2
Module Responsible	Prof. Christian Becker			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Electrical Engineering			
Educational Objectives	After taking part successfully, students have re	eached the following lea	Irning resul	ts
Professional Competence				
Knowledge	Students are able to give an overview of conventional and modern electric power systems. They can explain in detail and critically evaluate technologies of electric power generation, transmission, storage, and distribution as well as integration of equipment into electric power systems.			
Skills	With completion of this module the students are able to apply the acquired skills ir 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 a and represent their own work results in front o		cussions, a	dvance ideas
Autonomy	Students can independently tap knowledge of	the emphasis of the lec	tures.	
Workload in Hours	Independent Study Time 110, Study Time in L	ecture 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 - 150 minutes			
Assignment for the Following Curricula	Endineering. Elective Complificary			

Course L1670: Electric	cal Power Systems I: Introduction to Electrical Power Systems
Тур	Lecture
Hrs/wk	3
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 (n-1)-criterion symmetric failure calculations, short-circuit power control in networks and power stations grid planning power economy fundamentals
Literature	 K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, S Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017 R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

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	cal Power Systems I: Introduction to Electrical Power Systems
	Recitation Section (large)
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 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 (n-1)-criterion symmetric failure calculations, short-circuit power control in networks and power stations grid planning power economy fundamentals
Literature	 K. Heuck, KD. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017 R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

Module M1037: Engineering	Steam Turbines in Energy,	Environmental	and Po	wer Train
Courses				
Title Steam turbines in energy, (L1286)	, environmental and Power Train Engineering	Typ Lecture	Hrs/wk 3	CP 5
Steam turbines in energy, (L1287)	, environmental and Power Train Engineering	Recitation Section (sm	all) 1	1
Module Responsible	Prof. Alfons Kather			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully students have r	reached the following I	earning resul	its
Professional Competence				
Knowledge	 calculate thermodynamically a turbine calculate or estimate and further evalue outline diagrams describing the operation investigate the constructive aspective requirements the required construction discuss and argue on the operation c evaluate thermodynamically the integral 	nd constructive groups ng conditions for the ap and differentiate among resses and the con r e stage and a stage as uate sections of the tur ating range and the co pects and develop on characteristics haracteristics of different gration of different turbi	s of steam turk oplication of s g steam turbin structive and sembly bine nstructive cha from the th ent turbine typ ne designs in	team turbines nes according d operational aracteristics nermodynamic nes n heat cycles.
Skills	 In the module the students learn the fundame operational evaluation of complex plant, optimisations. They specifically: obtain the ability to analyse the potent thermodynamically, from the energetie can evaluate the performance and sources, for supplying base load and on the basis of the impact of power pladescribe the precautionary principles can describe the key requirements for Plants, based on the overriding demandant 	and gain in particul ntial of various energy c-economic and techn t technical limitations balancing reserve pow lant operation on the in for damage preventio or the Management and	ar confidence sources that of ical viewpoint in using va wer to the elect ntegrity of cor n d Design of T	ce in seeking can be utilised ts arious energy ctricity grid mponents, can Thermal Power
Personal Competence				

Social Competence	In the module the students learn: to work together with others whilst seeking a solution to assist each other in problem solving to conduct discussions to present work results to work respectfully within the team. 				
Autonomy	In the module the students learn the independent working of a complex theme whilst considering various aspects. They also learn how to combine independent functions in a system. The students become the ability to gain independently knowledge and transfer it also to new problem solving.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Course achievement	None				
	Written exam				
Examination duration and scale	180 min				
-	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				

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Course L1286: Steam	turbines in energy, environmental and Power Train Engineering
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
	 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

Content	 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 gas 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 manufacturing 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
Literature	 Traupel, W.: Thermische Turbomaschinen. Berlin u. a., Springer (TUB HH: Signatur MSI-105) Menny, K.: Strömungsmaschinen: hydraulische und thermische Kraft- und Arbeitsmaschinen. Ausgabe: 5. Wiesbaden, Teubner, 2006 (TUB HH: Signatur MSI-121) Bohl, W.: Aufbau und Wirkungsweise. Ausgabe 6. Würzburg, Vogel, 1994 (TUB HH: Signatur MSI-109) Bohl, W.: Berechnung und Konstruktion. Ausgabe 6. Aufl. Würzburg, Vogel, 1999 (TUB HH: Signatur MSI-110)

Course L1287: Steam t	Course L1287: Steam turbines in energy, environmental and Power Train Engineering			
Тур	Recitation Section (small)			
Hrs/wk	1			
СР				
Workload in Hours	dependent 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 M0512: Use of Solar Energy

Courses					
Title		Тур	Hrs/wk	СР	
Energy Meteorology (L00)	16)	Typ Lecture	1 1	1	
Energy Meteorology (L00	-	Recitation Section (small)	-	1	
Collector Technology (L00		Lecture	2	2	
Solar Power Generation (-	Lecture	2	2	
Module Responsible	Prof. Martin Kaltschmitt				
Admission					
Requirements	None				
Recommended Previous Knowledge	none				
Educational Objectives	After taking part successfully, students hav	ve reached the following lea	rning resu	lts	
Professional					
Competence					
Knowledge	With the completion of this module, students will be able to deal with technical foundations and current issues and problems in the field of solar energy and explain and evaulate these critically in consideration of the prior curriculum and current subject specific issues. In particular they can professionally describe the processes within a solar cell and explain the specific features of application of solar modules. Furthermore, they can provide an overview of the collector technology in solar thermal systems.				
Skills	Students can apply the acquired theoretical foundations of exemplary energy systems using solar radiation. In this context, for example they can assess and evaluate potential and constraints of solar energy systems with respect to different geographical assumptions. They are able to dimension solar energy systems in consideration of technical aspects and given assumptions. Using module-comprehensive knowledge students can evalute the economic and ecologic conditions of these systems. They can select calculation methods within the radiation theory for these topics.				
Personal Competence					
Social Competence	Students are able to discuss issues in the thematic fields in the renewable energ				
Autonomy	Students can independently exploit sources and acquire the particular knowledge about the subject area with respect to emphasis fo the lectures. Furthermore, with the assistance o lecturers, they can discrete use calculation methods for analysing and dimensioning solal energy systems. Based on this procedure they can concrete assess their specific learning level and can consequently define the further workflow.				
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84				
Credit points	6				
Course achievement					
Examination					
Examination duration and scale	3 hours written exam				
	Energy and Environmental Engineer Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems International Management and Engineer	ystems: Elective Compulsor	y		

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

Course L0016: Energy	Meteorology			
Тур	ecture			
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	 Introduction: radiation source Sun, Astronomical Foundations, Fundamentals of radiation Structure of the atmosphere Properties and laws of radiation Polarization Radiation quantities Planck's radiation law Wien's displacement law Stefan-Boltzmann law Kirchhoff's law Brightness temperature Absorption, reflection, transmission Radiation balance, global radiation, energy balance Atmospheric extinction Mie and Rayleigh scattering Radiative transfer Optical effects in the atmosphere 			
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 Meteorology			
Тур	Recitation Section (small)		
Hrs/wk			
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: Collect	or Technology			
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. 			



	Power Generation					
	Lecture					
Hrs/wk						
СР	2					
	Independent Study Time 32, Study Time in Lecture 28					
	Prof. Alf Mews, Martin Schlecht					
Language						
Cycle	SoSe					
Content	 Introduction Primary energy and consumption, available solar energy Physics of the ideal solar cell Light absorption PN junction characteristic values of the solar cell efficiency Physics of the real solar cell Charge carrier recombination characteristics, junction layer recombination, equivale circuit Increasing the efficiency Methods for increasing the quantum yield, and reduction of recombination Straight and tandem structures Hetero-junction, Schottky, electrochemical, MIS and SIS-cell tandem cell Concentrator Concentrator optics and tracking systems Technology and properties: types of solar cells, manufacture, single crystal silicon argallium arsenide, polycrystalline silicon, and silicon thin film cells, thin-film cells of carriers (amorphous silicon, CIS, electrochemical cells) Modules Circuits 					
Literature	 A. Götzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik, Teubn Studienskripten, Stuttgart, 1995 A. Götzberger: Sonnenenergie: Photovoltaik : Physik und Technologie der Solarzell Teubner Stuttgart, 1994 HJ. Lewerenz, H. Jungblut: Photovoltaik, Springer, Berlin, Heidelberg, New Yot 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 Energiewandlun Solarstrahlung, Halbleitereigenschaften und Solarzellenkonzepte, Teubner, Stuttga 1994 R. J. van Overstraeten, R.P. Mertens: Physics, technology and use of photovoltaic 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, Weinhei 2005 U. Rindelhardt: Photovoltaische Stromversorgung, Teubner-Reihe Umwelt, Stuttga 2001 V. Quaschning: Regenerative Energiesysteme, Hanser, München, 2003 G. Schmitz: Regenerative Energien, Ringvorlesung TU Hamburg-Harburg 1994/9 Institut für Energietechnik 					

ourses					
itle ombined Heat and Power ombined Heat and Power			Typ Lecture Recitation Section (I	Hrs/wk 3 arge) 1	CP 5 1
Module Responsible	Prof. Alfons Kather				
Admission Requirements	None				
Recommended Previous Knowledge			d II"		
Educational Objectives	After taking part su	ccessfully, students ha	ave reached the followin	g learning resu	Its
Professional Competence					
Knowledge	they can describe the behaviour of premixed flames and non-premixed flames, in order to describe the fundamentals of furnace design in gas-, oil- and coal combustion plant. The students are furthermore able to describe the formation of NO_x and the primary NO_x reduction measures, and evaluate the impact of regulations and allowable limit levels. The students present the layout, design and operation of Combined Heat and Power plants and are in a position to compare with each other district heating plants with back-pressure steam turbine or condensing turbine with pressure-controlled extraction tapping, CHP plants with gas turbine or with combined steam and gas turbine, or even district heating plants with an internal combustion engine. They can explain and analyse aspects of combined heat, power and cooling (CCHP) and describe the layout of the key components needed. Through this specialised knowledge they are able to evaluate the ecological significance of district CHP generation, as well as its economics.				
Skills	Using thermodynamic calculations and considering the reaction kinetics the students will be able to determine interdisciplinary correlations between thermodynamic and chemical processes during combustion. This then enables quantitative analysis of the combustion of gaseous, liquid and solid fuels and determination of the quantities and concentrations of the exhaust gases. In this module the first step toward the utilisation of an energy source (combustion) to provide usable energy (electricity and heat) is taught. An understanding of both procedures enables the students to holistically consider energy utilisation. Examples taken from the praxis, such as the CHP energy supply facility of the TUHH and the district heating network of Hamburg will be used, to highlight the potential from electricity generation plants with simultaneous heat extraction.				
	mass balances of combustion processes. Moreover, the students will gain a deep understanding of the combustion processes by the calculation of reaction kinetics.				
Personal					
Competence					

Autonomy manner the theoretical and practical knowledge from the lecture is consolidated and the potential impact of different process arrangements and boundary conditions highlighted.

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Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	oints 6				
Course achievement	Compulsory Bonus	s Form	Description Am Ende jeder Vorlesung wird schriftlich eine zu auswertende Kurzfrage (5-10 min) zu der Vorlesung der Vorwoche gestellt. In den Kurzfragen werden kleine Rechenaufgaben, Skizzen oder auch kleine Freitexte zur Beantwortung gestellt.		
	Written exam				
Examination duration and scale	120 min				
-	Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				

Тур	Lecture
Hrs/wk	
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Alfons Kather
Language	DE
Cycle	
	The subject area of "Combined Heat and Power" covers the following themes:
Content	 Layout, design and operation of Combined Heat and Power plants District heating plants with back-pressure steam turbine and condensing turbine wipressure-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 Combustion of gaseous fuels Combustion of glaseous 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 Verla 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-chemisch Grundlagen, Modellbildung, Schadstoffentstehung. Springer, Berlin [u. a.], 2001

Course L0220: Combin	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	Prof. Alfons Kather			
Language	DE			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M1182: Technical Elective Course for TMBMS (according to Subject Specific Regulations) Courses

TUHH

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

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Module M1161: T	urbomachinery					
Courses						
Title	Ту	р	Hrs/wk	СР		
Turbomachines (L1562)		cture	3	4		
Turbomachines (L1563)	Re	citation Section (large)	1	2		
Module Responsible						
Admission Requirements	None					
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, I	Heat Transfer				
Educational Objectives	After taking part successfully, students have reach	ned the following lea	rning result	S		
Professional						
Competence	The students can					
Knowledge	 distinguish the physical phenomena of conversion of energy, understand the different mathematic modelling of turbomachinery, calculate and evaluate turbomachinery. 					
	The students are able to					
Skills	- understand the physics of Turbomachinery,					
	- solve excersises self-consistent.					
Personal Competence						
	The students are able to					
Social Competence	 discuss in small groups and develop an approach. 					
	The students are able to					
	 develop a complex problem self-consister 	ht				
Autonomy	 analyse the results in a critical way, 					
	 have an qualified exchange with other stu 	dents.				
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ure 56				
Credit points						
Course achievement	None					
Examination						
Examination duration and scale	90 min					
Assignment for the Following Curricula	Energy Systems: Specialisation Marine Engineeri Energy Systems: Specialisation Energy Systems: Product Development, Materials and Product Elective Compulsory Product Development, Materials and Produc Compulsory Product Development, Materials and Produc Compulsory Theoretical Mechanical Engineering: Technical C	Elective Compulsory tion: Specialisation ction: Specialisation uction: Specialisation	Product E n Producti on Materia	on: Electiv als: Electiv		
	Theoretical Mechanical Engineering: Specialisati					

Course L1562: Turbon	nachines					
Тур	Lecture					
Hrs/wk	3					
СР	4					
Workload in Hours	dependent Study Time 78, Study Time in Lecture 42					
Lecturer	Prof. Dr. Karsten Meier					
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: Turbon	Course L1563: Turbomachines				
Тур	Recitation Section (large)				
Hrs/wk	1				
СР	2				
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14				
Lecturer	Prof. Dr. Karsten Meier				
Language	DE				
Cycle	SoSe				
Content	See interlocking course				
Literature	See interlocking course				

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Courses								
Title	Тур		Hrs/wk	СР				
Air Conditioning (L0594) Air Conditioning (L0595)	Lecture Recitation Se	ection (large)	3 1	5 1				
	Prof. Gerhard Schmitz	(
Admission Requirements	None							
Recommended Previous Knowledge	Technical Thermodynamics I. II. Fluid Dynamics. Heat Transfer							
Educational Objectives	After taking part successfully, students have reached the following learning results							
Professional Competence								
Knowledge	Students know the different kinds of air conditioning systems for buildings and mobile applications and how these systems are controlled. They are familiar with the change of state of humid air and are able to draw the state changes in a h1+x,x-diagram. They are able to calculate the minimum airflow needed for hygienic conditions in rooms and can choose suitable filters. They know the basic flow pattern in rooms and are able to calculate the ai velocity in rooms with the help of simple methods. They know the principles to calculate an ai duct network. They know the different possibilities to produce cold and are able to draw these processes into suitable thermodynamic diagrams. They know the criteria for the assessment or refrigerants.							
Skills	Students are able to configure air condition systems for buildings and mobile application They are able to calculate an air duct network and have the ability to perform simple plannir tasks, regarding natural heat sources and heat sinks. They can transfer research knowledge into practice. They are able to perform scientific work in the field of air conditioning.							
Personal Competence Social Competence	The students are able to discuss in small groups and develop an approach.							
Autonomy	Students are able to define independently tasks, to get new knowledge from existin knowledge as well as to find ways to use the knowledge in practice.							
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56							
Credit points	6							
Course achievement	None							
	Written exam							
Examination duration	60 min							

Assignment for the Following Curricula	Energy Systems: Specialisation Marine Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory
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Course L0594: Air Cor	nditioning						
Тур	Lecture						
Hrs/wk							
СР							
	lependent Study Time 108, Study Time in Lecture 42 of. Gerhard Schmitz						
Language							
Cycle							
	1. Overview						
	1.1 Kinds of air conditioning systems						
	1.2 Ventilating						
	1.3 Function of an air condition system						
	2. Thermodynamic processes						
	2.1 Psychrometric chart						
	2.2 Mixer preheater, heater						
	2.3 Cooler						
	2.4 Humidifier						
Content	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. Auflage, Deutscher Industrieverlag, 2013

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

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Courses								
Title Computational Fluid Dyna Computational Fluid Dyna Statistical Thermodynamic	mics in l	Process En	gineering (L	1052)		Typ Recitation Section (sr Lecture Lecture	Hrs/wk mall) 1 2 2	CP 1 2 3
Module Responsible	Prof. N	lichael Sch	ılüter					
Admission Requirements	None							
Recommended Previous Knowledge	Basic knowledge in Fluid Mechanics							
Educational Objectives	After ta	aking part s	uccessful	ly, student	s have re	ached the following	learning resu	Its
Professional Competence								
Knowledge	 After successful completion of the module the students are able to explain the the basic principles of statistical thermodynamics (ensembles, simp systems) describe the main approaches in classical Molecular Modeling (Monte Car Molecular Dynamics) in various ensembles discuss examples of computer programs in detail, 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 problems by Monte Carlo or molecul 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. 							
Personal Competence	The st	udents are	able to					
Social Competence	•	develop jo	pint solutio			and present them ir eir own contributio		her students
Autonomy	•	basis,	their learn			o define the followi eir profession.	ing steps of le	arning on th

Credit points	6
Course achievemen	t None
Examination	
Examination duration and scale	30 min
Assignment for the Following Curricula	 Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

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)

	Itational 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

Course L0099: Statistical Thermodynamics and Molecular Modelling			
Тур	Lecture		
Hrs/wk			
СР			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Dr. Sven Jakobtorweihen		
Language	EN		
Cycle	SoSe		
Content	 Some lectures will be carried out as computer exercises Introduction to Statistical Mechanics The ensemble concept The classical limit Intermolecular potentials, force fields Monte Carlo simulations (acceptance rules) (Übungen im Rechnerpool) (exercises in computer pool) Molecular Dynamics Simulations (integration of equations of motion, calculating transport properties) (exercises in computer pool) Molecular simulation of Phase equilibria (Gibbs Ensemble) Methods for the calculation of free energies 		
Literature	 Daan Frenkel, Berend Smit: Understanding Molecular Simulation, Academic Press M. P. Allen, D. J. Tildesley: Computer Simulations of Liquids, Oxford Univ. Press A.R. Leach: Molecular Modelling - Principles and Applications, Prentice Hall, N.Y. D. A. McQuarrie: Statistical Mechanics, University Science Books T. L. Hill: Statistical Mechanics , Dover Publications 		

TUHH Hamburg University of Technology

Typ Hrs.wk CP team Generators (L0213) Locture 3 5 module Responsible Prof. Allons Kather 1 1 Mone * "Technical Thermodynamics I and II" * * * "Heat Transfer" * * * * Professional Objectives After taking part successfully, students have reached the following learning results Professional Competence The students know the thermodynamic base principles for steam generators and steath the ecombu and fuel supply aspects of tossil-theled power plants. They can perform thermal de calculations and conceive the water-steam side, as well as they are able to define constructive details of the steam generators. The students can describe and evaluate operational behaviour of steam generators and explain these in the context of rel disciplines. The students will be able, using detailed knowledge on the calculation, design, construction of steam generators. Inteked with a wide theoretical and methodical foundate understand the mai	ourses				
Admission Requirements None Recommended Previous Knowledge • "Tachnical Thermodynamics I and II" • "Heat Transfer" • "Steam Power Plants" Educational Objectives • "Fluid Mechanics" • "Steam Power Plants" Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence The students know the thermodynamic base principles for steam generators and sketch the combu- and luel supply aspects of tossil-luelled power plants. They can perform thermal de constructive details of the steam generator. The students can describe and evaluate operational behaviour of steam generators and explain these in the context of rel disciplines. The students will be able, using detailed knowledge on the calculation, design, construction of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through proi definition and formalisation, modelling of processes, and training in the solution methode <i>Skills</i> paralial problems a good overview of this key component of the power plant wi obtained. Within the framework of the exercises the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to life tasks are solved, to highlight aspects of the design of steam generators. Social Competence Especially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific questror turber improve their understanding. Autonomm	itle team Generators (L0213) Le	ecture	3	5
Trequirements	Module Responsible	Prof. Alfons Kather			
Recommended Previous Knowledge • "Heat Transfer" • "Eluid Mechanics" • "Steam Power Plants" • Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence The students know the thermodynamic base principles for steam generators and their ty They are able to describe the basic principles of steam generators and sketch the combu- and fuel supply aspects of fossil-fuelled power plants. They can perform thermal de constructive details of the steam generators and explain these in the context of rel disciplines. Knowledge The students will be able, using detailed knowledge on the calculation, design, construction of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through proi definition and formalisation, modelling of processes, and training in the solution methodo for partial problems a good overview of this key component of the power plant will obtained. Within the framework of the exercise the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to lift tasks are solved, to highlight aspects of the design of steam generators. Social Competence Especially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific questor further improve their understanding. Autonomy The students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This w	Admission Requirements	None			
Objectives After taking part successfully, students have reached the following learning results Professional Competence The students know the thermodynamic base principles for steam generators and sketch the combu- and fuel supply aspects of fossil-fuelled power plants. They can perform thermal de calculations and conceive the water-steam side, as well as they are able to define constructive details of the steam generator. The students can describe and evaluate operational behaviour of steam generators and explain these in the context of rel disciplines. The students will be able, using detailed knowledge on the calculation, design, constructive of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through prof definition and formalisation, modelling of processes, and training in the solution method for partial problems a good overview of this key component of the power plant will obtained. Within the framework of the exercise the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to lift tasks are solved, to highlight aspects of the design of steam generators. Social Competence Especially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question further improve their understanding. Autonomy The students will be able to perform basic calculations covering aspects of the sto generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from diffic process schemata and bou		"Heat Transfer""Fluid Mechanics"			
Competence The students know the thermodynamic base principles for steam generators and sketch the combut and fuel supply aspects of fossil-fuelled power plants. They can perform thermal de calculations and conceive the water-steam side, as well as they are able to define constructive details of the steam generator. The students can describe and evaluate operational behaviour of steam generators and explain these in the context of rel disciplines. The students will be able, using detailed knowledge on the calculation, design, construction of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through prof botained. Skills The students will be able, using detailed knowledge on the calculation, design, construction of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through prof botained. Skills Within the framework of the exercise the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to life tasks are solved, to highlight aspects of the design of steam generators. Social Competence Especially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question further improve their understanding. Autonom The students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differences schemata and bound		After taking part successfully, students have reac	hed the following lea	rning resul	ts
They are able to describe the basic principles of steam generators and sketch the combut and fuel supply aspects of fossil-fuelled power plants. They can perform thermal de calculations and conceive the water-steam side, as well as they are able to define constructive details of the steam generator. The students can describe and evaluate operational behaviour of steam generators and explain these in the context of rel disciplines. The students will be able, using detailed knowledge on the calculation, design, construction of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through prot definition and formalisation, modelling of processes, and training in the solution methodo <i>Skills</i> for partial problems a good overview of this key component of the power plant will obtained. Within the framework of the exercise the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to lift tasks are solved, to highlight aspects of the design of steam generators. Personal Competence Especially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question further improve their understanding. Autonomy The students will be able to perform basic calculations covering aspects of the stig generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from diffe process schemata and boundary conditions are highlighted. Workload in Hours Independent Study Time 124, Study Time in Lecture 56					
construction of steam generators, linked with a wide theoretical and methodical foundation understand the main design and construction aspects of steam generators. Through prob definition and formalisation, modelling of processes, and training in the solution methodical for partial problems a good overview of this key component of the power plant will obtained.SkillsWithin the framework of the exercise the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to lift tasks are solved, to highlight aspects of the design of steam generators.Personal CompetenceEspecially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question further improve their understanding.AutonomyThe students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differ process schemata and boundary conditions are highlighted.Workload in HoursIndependent Study Time 124, Study Time in Lecture 56	Knowledge	constructive details of the steam generator. The students can describe and evaluate the operational behaviour of steam generators and explain these in the context of related			
design the steam generator and its components. For this purpose small but close to life tasks are solved, to highlight aspects of the design of steam generators. Personal Competence Especially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question further improve their understanding. Social Competence The students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differences schemata and boundary conditions are highlighted. Workload in Hours Independent Study Time 124, Study Time in Lecture 56	Skills	construction of steam generators, linked with a w understand the main design and construction as definition and formalisation, modelling of proces for partial problems a good overview of this	vide theoretical and n spects of steam gene ses, and training in th	nethodical rators. Thr ne solution	foundation, ough proble methodolo
CompetenceSocial CompetenceSocial CompetenceAutonomyThe students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differ process schemata and boundary conditions are highlighted.Workload in HoursIndependent Study Time 124, Study Time in Lecture 56		design the steam generator and its components	s. For this purpose s	mall but c	
Social Competence animates the students to reflect on their existing knowledge and ask specific question further improve their understanding. Autonomy The students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differences schemata and boundary conditions are highlighted. Workload in Hours Independent Study Time 124, Study Time in Lecture 56					
Autonomy generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differences schemata and boundary conditions are highlighted. Workload in Hours Independent Study Time 124, Study Time in Lecture 56	Social Competence	animates the students to reflect on their existin			
	Autonomy	generator, with only the help of smaller clues, practical knowledge from the lecture is consolid	on their own. This dated and the potent	way the th	eoretical a
	Workload in Hours	Independent Study Time 124, Study Time in Lect	ure 56		
Credit points 6	Credit points	6			



Course achievement	No 5 %	Excercises	Aufgabe (in ca. 5 min lösbar) zur Vorlesung der Vorwoche gestellt. Die Antworten müssen üblicherweise als Freitext gegeben werden, aber auch Zeichnungen, Stichpunkte oder, in seltenen Fällen, Multiple Choice sind möglich.
	Written exam		
Examination duration and scale	120 min		
•	Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		

Course L0213: Steam	Generators		
Тур	Lecture		
Hrs/wk			
СР	5		
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42		
Lecturer	Prof. Alfons Kather		
Language	DE		
Cycle	SoSe		
Content	 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, Barberton, Ohio, USA, 1992 		

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

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Module M0511: Electricity Generation from Wind and Hydro Power

		_		
Title		Тур	Hrs/wk	СР
Renewable Energy Projects in Emerged Markets (L0014)		Project Seminar	1	1
Hydro Power Use (L0013)		Lecture	1 2	1
Wind Turbine Plants (L00 ⁻ Wind Energy Use - Focus		Lecture Lecture	2	3 1
Module Responsible				
Admission				
Requirements	None			
	Module: Technical Thermodynamics I,			
Recommended	Module: Technical Thermodynamics II,			
Previous Knowledge	Module: Fundamentals of Fluid Mechan	ics		
Educational Objectives	After taking part successfully, students h	ave reached the following	learning resu	Its
Professional				
Competence				
Knowledge	By ending this module students can explain in detail knowledge of wind turbines particular focus of wind energy use in offshore conditions and can critical comment aspects in consideration of current developments. Furthermore, they are a describe fundamentally the use of water power to generate electricity. The students rep and explain the basic procedure in the implementation of renewable energy proj countries outside Europe.			omment thes are able ents reproduc
	Through active discussions of various topics within the seminar of the module improve their understanding and the application of the theoretical background and able to transfer what they have learned in practice.			
Skills	Students are able to apply the acquired theoretical foundations on exemplary water or win power systems and evaluate and assess technically the resulting relationships in the conte of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outsid Europe with the in principle applied approach in Europe and can apply this procedure of exemplary theoretical projects.			
Personal Competence				
Social Competence	Students can discuss scientific tasks subjet-specificly and multidisciplinary within a seminar		n a seminar.	
Autonomy	Students can independently exploit sources in the context of the emphasis of the lectur material to clear the contents of the lecture and to acquire the particular knowledge about th subject area.			
Workload in Hours	Independent Study Time 110, Study Tim	ne in Lecture 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	3 hours written exam			
	Civil Engineering: Specialisation Structu Civil Engineering: Specialisation Geote		• •	ry

	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory
	Energy and Environmental Engineering: Specialisation Energy Engineering: Elective
	Compulsory
	International Management and Engineering: Specialisation II. Renewable Energy: Elective
	Compulsory
	International Management and Engineering: Specialisation II. Energy and Environmental
	Engineering: Elective Compulsory
	Product Development, Materials and Production: Specialisation Product Development:
	Elective Compulsory
Following Curricula	Product Development, Materials and Production: Specialisation Production: Elective
	Compulsory
	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory
	Renewable Energies: Core qualification: Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory
	Process Engineering: Specialisation Environmental Process Engineering: Elective
	Compulsory
	Water and Environmental Engineering: Specialisation Environment: Compulsory
	Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

тур	Project Seminar
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Andreas Wiese
Language	DE
Cycle	SoSe
Content	 Introduction Development of renewable energies worldwide History Future markets Special challenges in new markets - Overview

ourse L0013: Hydro	Power Use	
Тур	Lecture	
Hrs/wk		
CP	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Stephan Heimerl	
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 T	urbine 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



ourse L0012: Wind E	nergy 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.: 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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Module M0508: F	luid Mechanics and (Ocean Energy			
		Securi Energy			
Courses					
Title		Тур		Hrs/wk	СР
Energy from the Ocean (L Fluid Mechanics II (L0001		Lecture Lecture		2 2	2 4
•	,	Lecture	2	<u>~</u>	7
	Prof. Michael Schlüter				
Admission Requirements	None				
Recommended Previous Knowledge	Wärma und Staffühartragun				
Educational Objectives	After taking part successfully	, students have reached th	e following lear	ning result	5
Professional Competence					
Knowledge	The students are able to describe different applications of fluid mechanics for the field o Renewable Energies. They are able to use the fundamentals of fluid mechanics fo calculations of certain engineering problems in the field of ocean energy. The students are able to estimate if a problem can be solved with an analytical solution and what kind o alternative possibilities are available (e.g. self-similarity, empirical solutions, numerica methods).				
Skills	Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are able to formulate momentum and mass balances to optimize the hydrodynamics of technical processes. They are able to transform a verbal formulate message into an abstract formal procedure.				
Personal Competence					
Social Competence	The students are able to discuss a given problem in small groups and to develop a approach. They are able to solve a problem within a team, to prepare a poster with the result and to present the poster.				•
Autonomy	Students are able to define i are able to work out the kno the basis of the existing know	wledge that is necessary			
Workload in Hours	Independent Study Time 124	I, Study Time in Lecture 56	6		
Credit points					
Course achievement		orm iroup discussion	Description	ו	
	Written exam				
Examination duration and scale	3h				
Assignment for the Following Curricula	Energy Systems: Core qualif International Management a Compulsory Renewable Energies: Core o Theoretical Mechanical Engi Theoretical Mechanical Engi	and Engineering: Speciali qualification: Compulsory ineering: Specialisation Er	sation II. Renew	Elective Co	mpulsory

Course L0002: Energy	from the Ocean
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE
Cycle	WiSe
Content	 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 M	echanics 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 technischer 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 M0658: Ir	nnovative	CFD App	roaches			
Courses						
Title Application of Innovative ((L0239)	CFD Methods ir	n Research and	d Development	Typ Lecture	Hrs/wk	СР 3
Application of Innovative ((L1685)	CFD Methods ir	n Research and	d Development	Recitation Section (small)	2	3
Module Responsible	Prof. Thomas	s Rung				
Admission Requirements	Nono					
	Attendance of	of a computati	onal fluid dynamics	course (CFD1/CFD2)		
Recommended Previous Knowledge	(:omnatant	•	of numerical analys	sis in addition to gen	eral and o	computational
Educational Objectives	After taking p	After taking part successfully, students have reached the following learning results				
Professional Competence						
Knowledge	Student can explain the theoretical background of different CFD strategies (e.g. Lattice- Boltzmann, Smoothed Particle-Hydrodynamics, Finite-Volume methods) and describe the fundamentals of simulation-based optimisation.					
Skills	Student is ab	le to identify	an appropriate CFD	-based solution strategy	y on a jusitfi	ed basis.
Personal						
Competence						
Social Competence	Student should practice her/his team-working abilities, learn to lead team sessions and present solutions to experts.					
-				m a simulation-based p	project indep	pendently,
		Study Time 1	24, Study Time in L	ecture 56		
Credit points		. Damua	F	Descriptio		
Course achievement	Compulsory Yes	20 %	Form Written elaboration	Descriptio	n	
Examination	Oral exam					
Examination duration and scale	30 min					
-	Naval Archite Ship and Offe Theoretical M Theoretical M	ecture and Oc shore Techno Mechanical En Mechanical En	ology: Core qualifica ngineering: Technic ngineering: Speciali	Compulsory Fore qualification: Electiv tion: Elective Compulso al Complementary Cour sation Energy Systems: Engineering: Elective C	ry rse: Elective Elective Co	e Compulsory

Course L0239: Applica	tion 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

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

Module M0515: Energy Information Systems and Electromobility

Courses				
Title		Тур	Hrs/wk	СР
-	II: Operation and Information Systems of Electrical	Lecture	2	4
Power Grids (L1696) Electro mobility (L1833)		Lecture	2	2
	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Electrical Engineering			
Educational Objectives	After taking part successfully, students have re	eached the following lea	arning resul	ts
Professional Competence				
Knowledge	Students are able to give an overview of the electric power engineering in the field of renewable energies. They can explain in detail the possibilities for the integration of renewable energy systems into the existing grid, the electrical storage possibilities and the electric power transmission and distribution, and can take critically a stand on it.			
Skills	With completion of this module the students are able to apply the acquired skills in applications of the design, integration, development of renewable energy systems and to assess the results.			
Personal Competence				
Social Competence	The students can participate in specialized a and represent their own work results in front o		cussions, a	dvance ideas
Autonomy	Students can independently tap knowledge o	f the emphasis of the le	ctures.	
Workload in Hours	Independent Study Time 124, Study Time in L	ecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Energy and Environmental Engineering: Engineering: Elective Compulsory Energy Systems: Specialisation Energy Syste Renewable Energies: Specialisation Wind En Renewable Energies: Specialisation Solar En Theoretical Mechanical Engineering: Speciali Theoretical Mechanical Engineering: Technic	ms: Elective Compulso ergy Systems: Elective ergy Systems: Elective sation Energy Systems	ry Compulsor Compulsor : Elective Co	y ompulsory

	cal Power Systems II: Operation and Information Systems of Electrical Power Grids
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	 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 / asse 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 asymmetric failure calculation state estimation E. Handschin: Elektrische Energieübertragungssysteme, Hüthig Verlag
Literature	E. Handschin: Elektrische Energieubertragungssysteme, Huthig Verlag B. R. Oswald: Berechnung von Drehstromnetzen, Springer-Vieweg Verlag V. Crastan: Elektrische Energieversorgung Bd. 1 & 3, Springer Verlag

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	Inhalt (englisch) 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
	Vorlesungsunterlagen/ lecture material

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Courses				
Fitle		Тур	Hrs/wk	СР
Electrical Installation on Sh	nips (L1531)	Lecture	2	2
Electrical Installation on Sh	nips (L1532)	Recitation Section (large) 1	1
Marine Engineering (L1569	-	Lecture	2	2
Marine Engineering (L157		Recitation Section (large) 1	1
A dmission	Prof. Christopher Friedrich Wirz			
Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stude	ents have reached the followir	ng learning resu	ilts
Professional Competence				
Knowledge	The students are able to describe the state-of-the-art regarding the wide range of propulsio components on ships and apply their knowledge. They further know how to analyze an optimize the interaction of the components of the propulsion system and how to describ complex correlations with the specific technical terms in German and English. The student are able to name the operating behaviour of consumers, describe special requirements on th design of supply networks and to the electrical equipment in isolated networks, as e.g onboard ships, offshore units, factories and emergency power supply systems, explain power generation and distribution in isolated grids, wave generator systems on ships, and nam requirements for network protection, selectivity and operational monitoring.			
Skills	The students are skilled to emp machinery, their selection and op analyse and solve technical and and to design propulsion syste correlations and bring them into co short-circuit currents, switchgear, a	peration on board ships. The operational problems with p ms. The students have the ontext with related disciplines.	y are further a opulsion and a skills to des Students are al	ble to asses auxiliary plar cribe compl ble to calcula
Personal Competence Social Competence	The students are able to communiship building and component supp		ofessional envir	ronment in tl
Autonomy	The widespread scope of gained I future profession independently an	-	nts to handle sit	uations in the
Workload in Hours	Independent Study Time 96, Study	Time in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration	90 minutes plus 20 minutes oral ex	am		

Assignment for the
Following CurriculaEnergy Systems: Specialisation Marine Engineering: CompulsoryTheoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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Course L1531: Electric	cal Installation on Ships				
Тур	Lecture				
Hrs/wk					
СР	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 Installation on Ships					
Тур	Typ 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 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	Typ 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.

0						
Courses						
Title Aircraft Systems I (L0735 Aircraft Systems I (L0739				Typ Lecture Recitation Section (large)	Hrs/wk 3 2	CP 4 2
Module Responsible	Prof. Fra	ank Thielecke				
Admission Requirements	None					
Recommended Previous Knowledge	•	nowledge in: Mathematics Mechanics Thermodynamics Electrical Engineering Hydraulics Control Systems	I			
Educational Objectives		king part successfully,	students have re	ached the following lea	rning resul	lts
Professional Competence						
Knowledge	 Students are able to: Describe essential components and design points of hydraulic, electrical and high-lift systems Give an overview of the functionality of air conditioning systems Explain the need for high-lift systems such as ist functionality and effects Assess the challenge during the design of supply systems of an aircraft 					
Skills	 Students are able to: Design hydraulic and electric supply systems of aircrafts Design high-lift systems of aircrafts Analyze the thermodynamic behaviour of air conditioning systems 					
Personal Competence		ts are able to:				

Autonomy	Students are able to:Reflect the contents of lectures autonomously				
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70				
Credit points	6				
Course achievement	None				
Examination					
Examination duration and scale	165 Minutes				
Assignment for the Following Curricula	Energy Systems: Specialisation Energy Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective				

Course L0735: Aircraf	t Systems I				
Тур	Lecture				
Hrs/wk	5				
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 				

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



Module	M0812:	Aircraft	Design
modalo		/ O. a	- 00.g.i

Courses				
Title	Тур	0	Hrs/wk	СР
Aircraft Design I (L0820)		ture	2	2
Aircraft Design I (L0834)	Rec	citation Section (large)	1	1
UAV) (L0844)	tual Design of Rotorcraft, special operations aircraft, Lec	ture	2	2
Aircraft Design II (Concep UAV) (L0847)	tual Design of Rotorcraft, special operations aircraft, Rec	citation Section (large)	1	1
Module Responsible	Prof. Volker Gollnick			
Admission Requirements	None			
Recommended Previous Knowledge	 Bachelor Mech. Eng. Vordiplom Mech. Eng. Module Air Transport Systems 			
Educational Objectives	After taking part successfully, students have reach	ed the following lear	rning results	i
Professional Competence				
Knowledge	 Principle understanding of integrated aircraft design Understanding of the interactions and contributions of the various disciplines Impact of the relevant design parameter on the aircraft design Introduction of the principle design methods 			
	Understanding and application of design and calc	ulation methods		
Skills	Understanding of interdisciplinary and integrative interdependencies			
Personal Competence				
	Working in interdisciplinary teams			
Social Competence	Communication			
Autonomy	Organization of workflows and -strategies			
Workload in Hours	Independent Study Time 96, Study Time in Lecture	e 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
_	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory			

Course L0820: Aircraft Design I			
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Volker Gollnick		
Language	DE		
Cycle	WiSe		
Content	 geometry) 7. Principles of engine design and integration 8. Cruise design 9. Design of runway and landing field length 10. Cabin design (fuselage dimensioning, cabin interior, loading systems) 11. System- and equipment aspects 12. Design variations and operating cost calculation 		
Literature	J. Roskam: "Airplane Design" D.P. Raymer: "Aircraft Design - A Conceptual Approach" J.P. Fielding: "Intorduction to Aircraft Design" Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"		

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

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

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

TUHH

Module M0771: F	light Physics			
Courses				
Title Aerodynamics and Flight I Flight Mechanics II (L0730 Flight Mechanics II (L0731))	Typ Lecture Lecture Recitation Section (large)	Hrs/wk 3 2 1	CP 3 2 1
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None			
Recommended Previous Knowledge	 Basic knowledge in: Mathematics Mechanics Thermodynamics Aviation 			
Educational Objectives	After taking part successfully, studer	nts have reached the following lea	rning resul	lts
Professional Competence Knowledge Skills				
Personal Competence Social Competence Autonomy				
	Independent Study Time 96, Study 1	Fime in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 Minutes (WS) + 90 Minutes (SS))		
Assignment for the Following Curricula	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

Course L0727: Aerody	namics 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 Mechanics II			
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Frank Thielecke, Mike Montel		
Language	DE		
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 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, Mike Montel	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1182: Technical Elective Course for TMBMS (according to Subject Specific Regulations) Courses

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Courses	
Title	Typ Hrs/wk CP
Module Responsible	Prof. Robert Seifried
Admission Requirements	None
Recommended Previous Knowledge	see FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge Skills	see FSPO see FSPO
Personal Competence	
Social Competence Autonomy	see FSPO see FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	

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Courses				
Title Systems Engineering (L15	•	Typ Lecture	Hrs/wk 3	CP 4
Systems Engineering (L1		Recitation Section (large)	I	2
Module Responsible Admission Requirements				
Requirements	None			
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Previous knowledge in: • Aircraft Cabin Systems			
Educational Objectives	After taking part successfully, students have re	ached the following lea	rning resul	ts
Professional Competence				
Knowledge	 Students are able to: understand systems engineering process models, methods and tools for the development of complex Systems describe innovation processes and the need for technology Management explain the aircraft development process and the process of type certification for aircraft explain the system development process, including requirements for systems reliability identify environmental conditions and test procedures for airborne Equipment value the methodology of requirements-based engineering (RBE) and model-based requirements engineering (MBRE) 			
Skills	Students are able to: • plan the process for the development of complex Systems • organize the development phases and development Tasks • assign required business activities and technical Tasks • apply systems engineering methods and tools			
Personal				
Competence Social Competence	Students are able to:			
Autonomy	Students are able to: • interact and communicate in a development team which has distributed tasks			
Workload in Hours	Independent Study Time 124, Study Time in Lo	ecture 56		
Credit points	6			
Course achievement	None			
Examination				
Examination duration	120 Minutes			

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

Course L1547: Systems Engineering		
Тур	Lecture	
Hrs/wk	3	
СР	ł	
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 integration of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineering process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known. Key aspects of the course are processes for innovation and technology management, system design, system integration and certification as well as tools and methods for systems engineering: • Innovation processes • IP-protection • Technology management • Systems engineering • Aircraft program • Certification issues • Systems development • Safety objectives and fault tolerance • Environmental and operating conditions • Tools for systems engineering • Requirements-based engineering (RBE) • Model-based requirements engineering (MBRE)	
Literature	 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: System	Course L1548: Systems Engineering				
Тур	Recitation Section (large)				
Hrs/wk	1				
СР	2				
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14				
Lecturer	Prof. Ralf God				
Language	DE				
Cycle	SoSe				
Content	See interlocking course				
Literature	See interlocking course				

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Тур		
Lecture	Hrs/wk 3	CP 4
Recitation Section (large	e) 2	2
,		
ully, students have reached the following le	earning resu	ilts
gear-systems in general along with corr	esponding s	properties an
er design process for the flight control actua ematics se landing gear systems	ators	
tions in mixed teams		
	-	
110, Study Time in Lecture 70		
JCG INCOMPANY	s gy sfully, students have reached the following le ucture of primary flight control systems as w ng gear-systems in general along with corr configurations and designs and their origin teric conditions for icing such as the function nt control actuation systems ller design process for the flight control actua inematics yse landing gear systems ystems lutions in mixed teams	s gy stully, students have reached the following learning resu ucture of primary flight control systems as well as actua ng gear-systems in general along with corresponding configurations and designs and their origins reric conditions for icing such as the functionality of anti- int control actuation systems ller design process for the flight control actuators inematics yse landing gear systems ystems lutions in mixed teams enents and perform appropriate yet simplified design from complex issues and circumstances in a self-reliant a 110, Study Time in Lecture 70

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

Course L0736: Aircraf	t Systems II
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-lce 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: Aircraf	course L0740: Aircraft Systems II				
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				

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Courses					
Title		Тур	Hrs/wk	СР	
Aircraft Cabin Systems (L		Lecture	3	4	
Aircraft Cabin Systems (L		Recitation Section (large)	1	2	
Module Responsible					
Admission Requirements	None				
	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems				
Educational Objectives	After taking part successfully, students	nave reached the following lea	rning resu	lts	
Professional Competence					
Knowledge	Students are able to: • describe cabin operations, equipment in the cabin and cabin Systems • explain the functional and non-functional requirements for cabin Systems • elucidate the necessity of cabin operating systems and emergency Systems • assess the challenges human factors integration in a cabin environment				
Skills	Students are able to: • design a cabin layout for a given business model of an Airline • design cabin systems for safe operations • design emergency systems for safe man-machine interaction • solve comfort needs and entertainment requirements in the cabin				
Personal Competence					
	Students are able to: • understand existing system solutions	and discuss their ideas with ex	perts		
	Students are able to: • Reflect the contents of lectures and ex	pert presentations self-depend	lent		
Workload in Hours	Independent Study Time 124, Study Tir	ne in Lecture 56			
Credit points	· · ·				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	120 Minutes				
Assignment for the	Electrical Engineering: Specialisation Compulsory Energy Systems: Specialisation Energy Aircraft Systems Engineering: Core qua International Management and Engir Compulsory Product Development, Materials and Elective Compulsory	v Systems: Elective Compulson alification: Compulsory neering: Specialisation II. Avi	y ation Syst	ems: Election	

Compu	lsory						
Produc	t Development,	Materials	and	Production:	Specialisation	Materials:	Elective
Compu	lsory						
Theore	tical Mechanical	Engineering	g: Spe	cialisation Ai	rcraft Systems E	Engineering:	Elective
Compu	lsory						
Theore	tical Mechanical E	Ingineering	: Tech	nical Compler	mentary Course:	Elective Cor	mpulsory

Course L1545: Aircraf	t 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 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 Systems				
Тур	Recitation Section (large)			
Hrs/wk	1			
СР	2			
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14			
Lecturer	Prof. Ralf God			
Language	DE			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

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Module M1213: A	vionics for s	afety-critical S	ystems			
Courses						
Title			Тур	Hrs/wk	СР	
Avionics of Safty Critical S			Lecture	2	3	
Avionics of Safty Critical S			Recitation Section (smal Practical Course		1 2	
Avionics of Safty Critical S			Practical Course	1	2	
Module Responsible Admission Requirements						
Requirements						
	Basic knowledge	e in:				
Recommended	 Mathema 	tics				
Previous Knowledge		Engineering				
	 Information 	S				
Educational	After taking part	successfully studen	ts have reached the following le	arning rocu	lte	
Objectives		successiony, studen	is have reached the following le	anning resu	115	
Professional						
Competence	Students can:					
	Siddenis can.					
	 describe 	the most important r	rinciples and components of sa	fety-critical	avionics	
	 denote processes and standards of safety-critical software development 					
Knowledge	 depict the principles of Integrated Modular Avionics (IMA) 					
			us systems used in avionics			
	 assess th 	e difficulties of deve	loping a safety-critical avionics s	system corre	ectly	
	Students can					
			and a first the the second			
		eal-time hardware a A653 applications	nd simulations			
Skills		nics architectures up	o to a certain extend			
		st scripts and assess				
Personal						
Competence						
	Students can:					
	 jointly develop solutions in inhomogeneous teams 					
Social Competence	 exchange information formally with other teams present development results in a convenient way 					
	 present o 	evelopment results	in a convenient way			
	Students can:					
Autonomy			for an avionics system		:	
Autonomy	 autonom 	busiy derive concep	ts for systems based on safety-c	niicai avion	ICS	
Workload in Houre	Independent Stu	dy Time 124, Study	Time in Lecture 56			
	independent 3lu	ay mine 124, Study				

Credit points	6				
	Compulsory	Bonus	Form		Description
Course achievement	Yes	None	Subject practical w	theoretical ork	and
Examination					
Examination duration and scale	30 min				
-	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory				

Course L1640: Avionic	es of Safty Critical Systems
Тур	Lecture
Hrs/wk	2
СР	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 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 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: Avionic	ourse L1652: Avionics of Safty Critical Systems	
Typ 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	

Hrs/wk

2

2

3

2

2

2

2

2

2

2

2

Typ Lecture

Lecture

Learning Lecture

Lecture

Lecture

Lecture

Lecture

Lecture

Lecture

Lecture

Project-/problem-based

Recitation Section (small) 1

Recitation Section (large) 1

Recitation Section (small) 1

Recitation Section (small) 1

СР

3

3

3

2

1

2

3

2

2

2

2

2

2

1

3

Module M1043: Aircraft Systems Engineering

Title Fatigue & Damage Tolerance (L0310) Lightweight Construction with Fibre Reinforced Rolymers - Structural Mechanics (L1514)		
Lightweight Design Practical Course (L1258)		
Aviation Security (L1549) Aviation Security (L1550) Mechanisms, Systems and Processes of Materials Testing (L0950) Turbo Jet Engines (L0908) System Simulation (L1820) System Simulation (L1821) Materials Testing (L0949) Reliability in Engineering Dynamics (L0176) Reliability in Engineering Dynamics (L1303) Reliability of avionics assemblies (L1554) Reliability of avionics assemblies (L1555) Reliability of Aircraft Systems (L0749)		
Module Responsible Prof. Frank Thielecke		
Admission Requirements		
Basic knowledge in: • Mathematics		

Courses

Requirements	
Recommended Previous Knowledge	Thermodynamics
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 systems engineering, air transportation system and material science 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 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	6
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory

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

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

Course L1514: Lightweight Construction with Fibre Reinforced Rolymers - Structural Mechanics	
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 scale	130 min
Lecturer	Prof. Benedikt Kriegesmann
Language	DE
Cycle	WiSe
	 Fundamentals of Anisotropic Elasticity Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law Behaviour of a single laminate layer Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules Fundamentals of Micromechanics of a laminate layer Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer Classical Laminate Plate Theory



	Notations and laminate code; Kinematics and displacement field; Strains and stresses, stress resultants; Constitutive equations and coupling effects; Special laminates and their behavior; Effective laminate properties
Content	Strength of Laminated Plates
	Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin
	Bending of Composite Laminated Plates
	Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions
	Stress Concentration Problems
	Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis
	Stability of Thin-Walled Composite Structures
	Buckling of anisotropic plates and shells; Influence of loading conditions; Influence of boundary conditions; Exact transcendental solutions and their evaluation; Buckling of stiffened composite plates; Minimum stiffness requirements; Local buckling of stiffener profiles
	Written exercise (report required)
	Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account
	 Schürmann, H., "Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. Wiedemann, J., "Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage.
Literature	 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.



Тур	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Dieter Krause
Language	DE/EN
Cycle	SoSe
Content	 getting familiar with fibre reinforced plastics as well as lightweight design Design of a sandwich structure made of fibre reinforced plastics using finite eleme 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, 200 Puck, A., "Festigkeitsanalsyse von Faser-Matrix-Laminaten", Hanser, München, Wie 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, F München, Carl Hanser Verlag, 2012. Schulte, K., Fiedler, B., "Structure and Properties of Composite Materials", Hambur 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 scale	90 Minuten	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	WiSe	
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization. The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization: • Historical development • The special role of air transport • Motive and attack vectors • The human factor • Threats and risk • Regulations and law • Organization and implementation of aviation security tasks • Passenger and baggage checks • Cargo screening and secure supply chain • Safety technologies	
Literature	 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	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	WiSe	
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization. The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization: • Historical development • The special role of air transport • Motive and attack vectors • The human factor • Threats and risk • Regulations and law • Organization and implementation of aviation security tasks • Passenger and baggage checks • Cargo screening and secure supply chain • Safety technologies	
Literature	 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 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	
Examination duration and scale	90 Minuten
Lecturer	Dr. Jan Oke Peters
Language	DE
Cycle	SoSe
Content	 Application, analysis and discussion of basic and advanced testing methods to ensure correct selection of applicable testing procedure for investigation of part/materials deficiencies Stress-strain relationships Strain gauge application Visko elastic behavior Tensile test (strain hardening, necking, strain rate) Compression test, bending test, torsion test Crack growth upon static loading (J-Integral) Crack growth upon cyclic loading (micro- und macro cracks) Effect of notches Creep testing (physical creep test, influence of stress and temperature, Larson Miller parameter) Wear testing Non destructive testing application for overhaul of jet engines
Literature	 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 L0908: Turbo Jet Engines		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
	Mündliche Prüfung	
Examination duration and scale	45 min	
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 	

Tvn	Lecture	
Hrs/wk		
CP		
	Independent Study Time 32, Study Time in Lecture 28	
	Mündliche Prüfung	
Examination duration and scale	30 min	
Lecturer	Dr. Stefan Wischhusen	
Language	DE	
Cycle	WiSe	
Content	 All participants must bring a notebook, to install and use the software 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: Heat transfer Example: System with different subsystems 	
Literature	 [1] Modelica Association: "Modelica Language Specification - Version 3.3", Linköpir Sweden, 2012 [2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. [3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. [4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3. Wiley-IEEE Press, New York, 2015. [5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Syste with Modelica", Wiley, New York, 2011. 	

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



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



Course L0176: Reliability in Engineering Dynamics		
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form		
Examination duration and scale	90 min.	
Lecturer	Prof. Uwe Weltin	
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	
Examination duration and scale	90 min
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1554: Reliabi	lity of avionics assemblies	
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form		
Examination duration and scale	90 Minuten	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed: Survey of the role of electronics in aviation System levels: From silicon to mechatronic systems Semiconductor components, assemblies, systems Challenges of electronics: Requirements for AVT Methods and techniques of AVT Error patterns for assemblies and avoidance of errors Reliability of Avionics COTS, ROTS, MOTS and the F³I concept Future challenges for electronics 	
Literature	- Skript zur Vorlesung Hanke, HJ.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999	



Course L1555: Reliability of avionics assemblies		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed: Survey of the role of electronics in aviation System levels: From silicon to mechatronic systems Semiconductor components, assemblies, systems Challenges of electronics: Requirements for AVT Methods and techniques of AVT Error patterns for assemblies and avoidance of errors Reliability analysis for printed circuit boards (PCBs) Reliability of Avionics COTS, ROTS, MOTS and the F³I concept Future challenges for electronics 	
Literature	- Skript zur Vorlesung Hanke, HJ.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999	

Course L0749: Reliabi	lity of Aircraft Systems	
Тур	Lecture	
Hrs/wk		
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form		
Examination duration and scale	90 Minuten	
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 	

TUHH Hamburg University of Technology

Courses				
Title		Тур	Hrs/wk	СР
Computer and communication technology in cabin electronics and avionics (L1557)		Lecture	2	2
Computer and communication technology in cabin electronics and avionics (L1558)		Recitation Section (small)	1	1
Model-Based Systems En	gineering (MBSE) with SysML/UML (L1551)	Project-/problem-based Learning	3	3
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Previous knowledge in: • Systems Engineering			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	 Students are able to: describe the structure and operation of computer architectures explain the structure and operation of digital communication Networks explain architectures of cabin electronics, integrated modular avionics (IMA) and Aircraf Data Communication Network (ADCN) understand the approach of Model-Based Systems Engineering (MBSE) in the design o hardware and software-based cabin systems 			
Skills	Students are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate with other network participants • connect a minicomputer with a cabin management system (A380 CIDS) and communicate over a AFDX®-Network • model system functions by means of formal languages SysML/UML and generate software code from the models • execute software code on a minicomputer			
Personal Competence				
	Students are able to: • elaborate partial results and merge with oth	ers to form a complete sc	olution	
Autonomy	Students are able to: • organize and schedule their practical tasks			
Workload in Hours	Independent Study Time 96, Study Time in Le	ecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			

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

Course L1557: Computer and communication technology in cabin electronics and avionics			
Тур	Lecture		
Hrs/wk	2		
СР	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: e History of computer and network technology e Computer and perating system (OS) e Programming languages (machine code and high-level languages) e Applications and Application Programming Interfaces (serial, USB, Ethernet) Layer model in network technology Network topologies e Network components exercise (IMA) and Aircraft Data Communication Networks (ADCN) cabin electronics and cabin networks (ADCN) cabin electronics and cabin networks (ADCN) computer architectures (PC, IPC, Embedded Systems) e BIOS, UEFI and operating system (OS) e Programming languages (machine code and high-level languages) e Applications and Application Programming Interfaces e External interfaces (serial, USB, Ethernet) e Layer model in network technology e Network topologies e Network topologies e Network components endored and Aircraft Data Communication Networks (ADCN) e Cabin electronics and cabin networks endored		
Literature	 Skript zur Vorlesung Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004 Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006 		

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

Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML		
Тур	Project-/problem-based Learning	
Hrs/wk	3	
СР	3	
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal languages SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Based Systems Engineering (MBSE) on a realistic hardware platform (e.g. Arduino®, Raspberry Pi®): • What is a model? • What is Systems Engineering? • Survey of MBSE methodologies • The modelling languages SysML /UML • Tools for MBSE • Best practices for MBSE • Requirements specification, functional architecture, specification of a solution • From model to software code • Validation and verification: XiL methods • Accompanying MBSE project	
Literature	 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 	

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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: N	larine Auxiliaries			
Courses				
Title		Тур	Hrs/wk	СР
Electrical Installation on Sl	hips (L1531)	Lecture	2	2
Electrical Installation on S		Recitation Section (large)	1	1
Auxiliary Systems on Boa		Lecture	2	2
Auxiliary Systems on Boa		Recitation Section (large)	1	1
Module Responsible Admission	Prof. Christopher Friedrich Wirz			
Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students have re	eached the following lea	rning result	S
Professional Competence				
Knowledge	 The students are able to name the operating behaviour of constant describe special requirements on the equipment in isolated networks, as e emergency power supply systems, explain power generation and distribution on ships, name requirements for network protect name the requirements regarding development, as well as describe operating procedures of equisitions ships and derive requirements for processing the students are able to 	design of supply netwo .g. onboard ships, offsh ution in isolated grids, y tion, selectivity and oper marine equipment a ipment components of s	nore units, wave gene rational mor and apply	factories ar rator systen nitoring, to produ
Skills	 calculate short-circuit currents, switchgear, design electrical propulsion systems for ships design additional machinery components, as to apply basic principles of hydraulics and to 	s well as	ems.	
Personal Competence	The students are able to communicate and	cooperate in a professi	onal envirc	onment in th
Social Competence	shipbuilding and component supply industry.			

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

Course L1531: Electrical Installation on Ships	
Тур	Lecture
Hrs/wk	2
СР	2
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 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

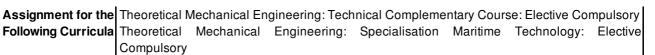
Course L1249: Auxilia	Course L1249: Auxiliary Systems on Board of Ships	
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Christopher Friedrich Wirz	
Language	DE	
Cycle	SoSe	
Content	 Vorschriften zur Schiffsausrüstung Ausrüstungsanlagen 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	
	Siehe korrespondierende Vorlesung
Literature	

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Module M1177: Maritime Technology and Maritime Systems

Title	I	Гур	Hrs/wk	СР
Analysis of Maritime Syste		_ecture	2	2
Analysis of Maritime Syste		Recitation Section (small)		1
Introduction to Maritime Te Introduction to Maritime Te		Lecture Recitation Section (small)	2 1	2 1
	Prof. Moustafa Abdel-Maksoud	(-	-
Admission				
Requirements	None			
Recommended Previous Knowledge	Solid knowledge and competences in mechanics, fluid dynamics and analysis (series periodic functions, continuity, differentiability, integration, multiple variables, ordinaray and partial differential equations, boundary value problems, initial conditions and eigenvalue problems).			
Educational Objectives	After taking part successfully, students have rea	ched the following lear	rning resul	ts
Professional				
Competence	After successful completion of this class, studen	te chauld have an over	wiow abou	it phonomo
	and methods in ocean engineering and the presented.			•
	In detail, the students should be able to			
Knowledge	 describe the different aspects and topics in Maritime Technology, apply existing methods to problems in Maritime Technology, discuss limitations in present day approaches and perspectives in the future, Techniques for the analysis of offshore systems, Modeling and evaluation of dynamic systems, System-oriented thinking, decomposition of complex systems. 			
Skills	The students learn the ability of apply and trans questions in maritime technologies. Furthermo developments will be discussed.			
Personal				
Competence				
Social Competence	The processing of an exercise in a group communication and team-working skills and thu subsequent working days. The collaboration ha of the results.	us promote an importai	nt working	technicque
Autonomy	The course contents are absorbed in an exercis a final exam in which a self-reflection of the lear			lly checked
Workload in Hours	Independent Study Time 96, Study Time in Lect	ure 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration				



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Course L0068: Analys	is of Maritime Systems
Тур	Lecture
Hrs/wk	2
СР	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: Analys	Course L0069: Analysis of Maritime Systems	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	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 to Maritime Technology	
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Sven Hoog
Language	DE
Cycle	WiSe
Content	 Introduction Ocean Engineering and Marine Research The potentials of the seas Industries and occupational structures Coastal and offshore Environmental Conditions Physical and chemical properties of sea water and sea ice Flows, waves, wind, ice Biosphere Response behavior of Technical Structures 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 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

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C oursee			
Title	and Offshore Structures (L1521)	Typ Lecture	Hrs/wk CP 2 3
	and Offshore Structures (L1521)	Recitation Section (-
Module Responsible	Prof. Sören Ehlers		
Admission Requirements			
Recommended Previous Knowledge	Structural analysis of ships and/or offshore structures and fundamental knowledge in		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional			
Competence			
	Students are able to		
Knowledge	 <i>Knowledge</i> 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 lift prediction based on the crack propagation.		
Personal			
Competence			
Social Competence	The students are able to communicate and cooperate in a professional environment in th shipbuilding and component supply industry.		
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in thei future profession independently and confidently.		
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	L30 min		
Assignment for the Following Curricula	T LINGORATICAL MIGCHANICAL ENGINGARING' LACONICAL (AMDIAMANTARV L'AURCA' EIACTIVA (AMDIJICAR		

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

Course L1522: Fatigue	ourse 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		



Module M0663: N	larine Geotechnics and Numerics			
Courses				
Title		Тур	Hrs/wk	СР
Marine Geotechnics (L054		Lecture	1	2
Marine Geotechnics (L05-		Recitation Section (large)	2	1
Numerical Methods in Ge	otechnics (L0375)	Lecture	3	3
Module Responsible	Prof. Jürgen Grabe			
Admission Requirements	None			
De service de d	complete modules: Geotechnics I-II, Mathemati	cs I-III		
Recommended Previous Knowledge	courses: Soil laboratory course			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional				
Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy		1		
	Independent Study Time 96, Study Time in Lec	ture 84		
Credit points				
Course achievement				
Examination				
Examination duration and scale	90 min			
Assignment for the Following Curricula				

Course L0548: Marine	Geotechnics
Тур	Lecture
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	Course L0549: Marine Geotechnics	
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	1	
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28	
Lecturer	Prof. Jürgen Grabe	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0375: Numerical Methods in Geotechnics		
Тур	Lecture	
Hrs/wk	3	
СР	3	
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Dr. Hans Mathäus Stanford	
Language	DE	
Cycle	SoSe	
Content	Topics: • numerical simulations • numerical algorithms • finite element method • application of finite element method in geomechanics • constitutive models for soils • contact models for soil structure interaction • selected applications	
Literature	 Wriggers P. (2001): Nichtlineare Finite-Elemente-Methoden, Springer Verlag, Berlin Bathe Klaus-Jürgen (2002): Finite-Elemente-Methoden. Springer Verlag, Berlin 	

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Module M1132: M	laritime Transport			
Courses Title		Тур	Hrs/wk	СР
Maritime Transport (L006) Maritime Transport (L006)		Lecture Recitation Section (small	2) 2	3 3
Module Responsible	Prof. Carlos Jahn			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached the following lea	arning resu	Its
Professional Competence				
Knowledge	 The students are able to present the actors involved in the maritime transport chain with regard to their typical tasks; name common cargo types in shipping and classify cargo to the corresponding categories; explain operating forms in maritime shipping, transport options and management in transport networks; weigh the advantages and disadvantages of the various modes of hinterland transport and apply them in practice; present relevant factors for the location planning of ports and seaport terminals and discuss them in a problem-oriented way; estimate the potential of digitisation in maritime shipping. 			
Skills	 The students are able to determine the mode of transport, actors and functions of the actors in the maritime supply chain; identify possible cost drivers in a transport chain and recommend appropriate proposals for cost reduction; record, map and systematically analyse material and information flows of a maritime logistics chain, identify possible 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 is everyday life; 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 the work out the respective advantages. 			
Personal Competence				
Social Competence	 The students are able to discuss and organise extensive work packages in groups; document and present the elaborated results. 			
	The students are capable to	voturo includina standarda -	nd avidalia	
Autonomy	research and select technical lite	erature, including standards a	na guideilr	ies;

eoretical Mechanical Engineering"	TUHHH Hamburg University of Technology
• submit own shares in an extensive written elaboration in small groups in due ti	me.
	I

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points			
-	Compulsory Bonus	Form	Description
Course achievement	No 15%	practical work	Teilnahme an einem Planspiel und anschließende schriftliche Ausarbeitung
	Written exam		
Examination duration and scale	120 minutes		
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		

Course L0063: Maritime Transport		
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	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: Maritim	ne 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. 		

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Module M1133: F	Port Logistics			
Courses				
Title Port Logistics (L0686) Port Logistics (L1473)		Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. Carlos Jahn			
Admission Requirements	None			
Recommended Previous Knowledge	none			
Educational Objectives	After taking part successfully, students h	ave reached the following lea	rning resu	lts
Professional Competence				
Knowledge	 The 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 the relevant operator models) and place them in their historical context; explain and evaluate different types of seaport terminals and their specific characteristics (cargo, transhipment technologies, logistic functional areas); analyze common planning tasks (e.g. berth planning, stowage planning, yard planning) at seaport terminals and develop suitable approaches (in terms of methods and tools) to solve these planning tasks; identify future developments and trends regarding the planning and control of innovative seaport terminals and discuss them in a problem-oriented manner. 			
Skills	 recognize functional areas in portional define and evaluate suitable operimeter operform static calculations with capacity (parking spaces, equip selected terminal types; reliably estimate which boundar the static planning of selected terminal se	rating systems for container te regard to given boundary o ment requirements, quay wall y conditions influence commo	conditions, I length, p on logistic	ort access) or
Personal Competence Social Competence	After completing the module, students ca transfer the acquired knowledge discuss and successfully organiz	to further questions of port log e extensive task packages in k results in writing in an ur	small grou	
	After completing the module, the studen	is are able to		
	[105]			

Autonomy	 research and select specialist literature, including standards, guidelines and journal papers, and to develop the contents independently; submit own parts in an extensive written elaboration in small groups in due time and to present them jointly within a fixed time frame.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	Compulsory BonusFormDescriptionNo15 %Written elaboration
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

ourse L0686: Port Lo	gistics
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 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 off 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 internationale 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 Lo	gistics
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.

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Module M1021: M	larine Diesel Er	ngine Plants				
Courses						
Title			Тур	Hrs/wk	СР	
Marine Diesel Engine Plan			Lecture	3	4	
Marine Diesel Engine Plan	· ·		Recitation Sectior	(large) i	2	
Module Responsible	-	edrich Wirz				
Admission Requirements	None					
Recommended Previous Knowledge						
Educational Objectives	After taking part suce	cessfully, students h	nave reached the follow	ving learning resu	ilts	
Professional						
Competence	Students can					
		pes four / two-stroke	e engines and assign ty	pes to given engi	nes,	
Knowledge	 name definitions ar 	nd characteristics, a	as well as			
	elaborate on specia	al features of the he	eavy oil operation, lubri	cation and coolin	g.	
	Students can					
	• evaluate the interaction of ship, engine and propeller,					
Skills	• use relationships between gas exchange, flushing, air demand, charge injection and combustion for the design of systems,					
	• design waste heat recovery, starting systems, controls, automation, foundation and design machinery spaces , and					
	 apply evaluation m 	 apply evaluation methods for excited motor noise and vibration. 				
Personal Competence						
Social Competence	The students are at shipbuilding and co		e and cooperate in a p lustry.	professional envi	ronment in the	
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.					
Workload in Hours	Independent Study	Time 124, Study Tin	ne in Lecture 56			
Credit points		-				
Course achievement	None					
Examination	Oral exam					
Examination duration and scale	20 min					
-	Energy Systems: Sp Naval Architecture a Theoretical Mechan	ecialisation Marine nd Ocean Enginee ical Engineering: Te	Y Systems: Elective Con Engineering: Compuls ring: Core qualification echnical Complementa g: Specialisation Ma	ory : Elective Compul	e Compulsory	



Course L0637: Marine	Diesel Engine Plants		
Тур	Lecture		
Hrs/wk	3		
СР	4		
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	rof. 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 Engine Plants		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	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	

Module M1175: Speed Water Ver	Special Topics of Ship nicles	Propulsionand	Hydrodynamic	s of High	
Courses					
Title Hydrodynamics of High S Special Topics of Ship Pro	peed Water Vehicles (L1593) opulsion (L1589)	Typ Lecture Lecture	Hrs/wk 3 3	CP 3 3	
Module Responsible	Prof. Moustafa Abdel-Maksoud				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge on ship resistan	ce, ship propulsion and p	ropeller theory		
Educational Objectives	After taking part successfully, stud	After taking part successfully, students have reached the following learning results			
Professional Competence					
Knowledge	 Understand present research questions in the field of ship propulsion Explain the present state of the art for the topics considered Apply given methodology to approach given problems 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 systems under different operation conditions by using simplified methods evaluate critically the investigation results of experimental or numerical investigations 				
Personal Competence	Students are able to				
Social Competence		÷ .	cument the correspor	nding results	
Autonomy	Students are able to assess their I	knowledge by means of e	xercises and case stu	udies	
Workload in Hours	Independent Study Time 96, Stud	y Time in Lecture 84			
Credit points	6				
Course achievement					
	Written exam				
Examination duration and scale	180 min				
Assignment for the Following Curricula	Naval Architecture and Ocean En Theoretical Mechanical Engineeri Theoretical Mechanical Engin Compulsory		ntary Course: Elective	e Compulsory	

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Course L1593: Hydrod	lynamics of High Speed Water Vehicles
Тур	Lecture
Hrs/wk	3
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	 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 Ship Propulsion
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	 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 M1182: Technical Elective Course for TMBMS (according to Subject Specific Regulations) Courses Title Typ Hrs/wk CP

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Title	Тур Н	rs/wk	СР
Module Responsible	Prof. Robert Seifried		
Admission Requirements			
Recommended Previous Knowledge	ISAA ESP()		
Educational Objectives	After taking part successfully, students have reached the following learni	ing results	3
Professional Competence			
Knowledge Skills	see FSPO see FSPO		
Personal Competence			
Social Competence	see FSPO		
Autonomy	see FSPO		
Workload in Hours	Depends on choice of courses		
Credit points	6		
Assignment for the Following Curricula		Engineer Elective C Technolog ective Col Comput	ing: Elective ompulsory gy: Elective mpulsory ter Science

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

Course L1528: Ship Vibration	
Тур	Lecture
Hrs/wk	2
СР	3
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
	 Introduction; assessment of vibrations Basic equations Beams with discrete / distributed masses Complex beam systems Vibration of plates and Grillages Deformation method / practical hints / measurements Hydrodynamic masses Spectral method Hydrodynamic masses acc. to Lewis Damping Shaft systems Propeller excitation Engines
Literature	Siehe Vorlesungsskript

Course L1529: Ship Vibration	
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	 Introduction; assessment of vibrations Basic equations Beams with discrete / distributed masses Complex beam systems Vibration of plates and Grillages Deformation method / practical hints / measurements Hydrodynamic masses Spectral method Hydrodynamic masses acc. to Lewis Damping Shaft systems Propeller excitation Engines
Literature	Siehe Vorlesungsskript



Module M1268: L	inear and Nonlinear Waves.			
Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear Wav	res (L1737)	Project-/problem-based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	Good Knowledge in Mathematics, Me	chanics and Dynamics.		
Educational Objectives	After taking part successfully, students have reached the following 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 nove methods and procedures.			
Personal				
Competence Social Competence	Students can reach working results also i	aroups		
Autonomy	Students are able to approach given re		dentify and	follow up nove
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 scale	2 Hours			
Assignment for the Following Curricula	Naval Architecture and Ocean Engineering. Core qualification. Elective Compulsory			

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	
Language	DE/EN	
Cycle	WiSe	
Content	Introduction into the Dynamics of Linear and Nonlinear Waves.	
	G.B. Witham, Linear and Nonlinear Waves. Wiley 1999.	
Literature	C.C. Mei, Theory and Applications of Ocean Surface Waves. World Scientific 2004.	

Module M1148: Selected topics in Naval Architecture and Ocean Engineering

Courses			
Title	Тур	Hrs/wk	СР
Outfitting and Operation of Special Purpose Offshore Ships (L1896)	Lecture	2	3
Design of Underwater Vessels (L0670)	Lecture	2	3
Lattice-Boltzmann methods for the simulation of free surface flows (L2066)	Lecture	2	3
Modeling and Simulation of Maritime Systems (L2013)	Project-/problem-based Learning	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 and Theoretical Fluiddynamics (L0240)	Lecture	2	3
Technical Elements and Fluid Mechanics of Sailing Ships (L0873)	Lecture	2	3
Technology of Naval Surface Vessels (L0765)	Lecture	2	3

Module Responsible	Prof. Sören Ehlers	
Admission Requirements	None	
Recommended Previous Knowledge	nono	
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 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 supply 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		

Course L1896: Outfitti	ng and 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	
	Mündliche Prüfung	
Examination duration and scale	30 min	
Lecturer	Dr. Hendrik Vorhölter	
Language		
Cycle	SoSe	
Content	The lecture is separated into two parts. In the first part some basic skills necessary for the design of offshore vessels and their equipment will be repeated and where necessary deepened. In particular, the specialties which are common for the 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 - Heavy lift and offshore construction vessels - Dredgers and rock dumping 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	Lecture
Hrs/wk	2
СР	
	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Peter Hauschildt
Language	
Cycle	
	The lectures will give an overview about the design of underwater vessels. The Topics are:
	1.) Special requirements on the design of modern, konventional submarines
	2.) Design history
	3.) Generals description of submarines
	4.) Civil submersibles
	5.) Diving, trim, stability
	6.) Rudders and Propulsion systems
	7.) Air Independent propulsion
	8.) Signatures
Content	9.) Hydrodynamics and CFD
	10.) Weapon- and combatmangementsystems
	11.) Safety and rescue
	12.) Fatigue and shock
	13.) Ships technical systems
	14.) Electricals Systems and automation
	15.) Logisics
	16.) Accomodation
	Some of the lectures will be Hheld in form of a excursion to ThyssenKrupp Marine Systems in Kiel
Literature	Gabler, Ubootsbau

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

Course L2013: Modelin	ng 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
	Mündliche Prüfung
Examination duration and scale	30 min
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 scale	45 min		
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
	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Dietrich Wittekind
Language	DE
Cycle	SoSe
Content	
Literature	

Course L0352: Ship Dynamics		
Тур	Lecture	
Hrs/wk	2	
СР	3	

Examination duration	
Examination duration and scale	60 min
Lecturer	Prof. Moustafa Abdel-Maksoud
Language	DE
Cycle	SoSe
Content	 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 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 un Schiffstheorie, Technische Universität Hamburg-Harburg, 2014 Abdel-Maksoud, M., Ship Dynamics, Lecture notes, Institute for Fluid Dynamic an Ship Theory, Hamburg University of Technology, 2014 Bertram, V., Practical Ship Design Hydrodynamics, Butterworth-Heinemann, Linac House - Jordan Hill, Oxford, United 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-Verla Berlin Heidelberg, Deutschland, 1992 Faltinsen, O. M., Sea Loads on Ships and Offshore Structures, Cambridge Univers Press, United Kingdom, 1990 Handbuch der Werften, Deutschland, 1986 Jensen, J. J., Load and Global Response of Ships, Elsevier Science, Oxford, Unit Kingdom, 2001 Lewis, Edward V. (ed.), Principles of Naval Architecture - Motion in Waves an Controllability, Society of Naval Architects and Marine Engineers, Jersey City, N 1989 Lewandowski, E. M., The Dynamics of Marine Craft: Maneuvering and Seakeepir World Scientific, USA, 2004 Lloyd, A., Ship Behaviour in Rough Weather, Gosport, Chichester, Sussex, Unit 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		
Examination duration and scale	30 min	
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 Elements and Fluid Mechanics of Sailing Ships		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form		
Examination duration and scale	30 min	
	Prof. Thomas Rung, DiplIng. Peter Schenzle	
Language		
Cycle		
	Principles of Sailing Mechanics:	
	- Sailing: Propulsion from relative motion	
	- Lifting foils: Sails, wings, rudders, fins, keels	
	- Wind climate: global, seasonal, meteorological, local	
	- Aerodynamics of sails and sailing rigs	
	- Hydrodynamics of Hulls and fins	
	Technical Elements of Sailing:	
	- Traditional and modern sail types	
Content	- Modern and unconventional wind propulsors	
	- Hull forms and keel-rudder-configurations	
	- Sailing performance Prediction (VPP)	
	- Auxiliary wind propulsion (motor-sailing)	
	Configuration of Sailing Ships:	
	- Balancing hull and sailing rig	
	- Sailing-boats and -yachts	
	- Traditional Tall Sailing Ships	
	- Modern Wind-Ships	
Literature	 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 Naval Surface Vessels		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
	Mündliche Prüfung	
Examination duration and scale	30 min	
Lecturer	Dr. Martin SchötteIndreyer	
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) 	

Modulo M1222: A				
	Arctic Technology			
Courses				
Title Ice Engineering (L1607) Ice Engineering (L1615)		Typ Lecture Recitation Section (small)	Hrs/wk 2 1	CP 2 2
Ship structural design for	arctic conditions (L1575)	Project-/problem-based Learning	2	2
Module Responsible	Prof. Sören Ehlers			
Admission Requirements	None			
Recommended Previous Knowledge	none			
Educational Objectives	After taking part successfully, students have	reached the following lea	rning result	S
Professional Competence				
Knowledge	The challenges and requirements due to ice can be explained. Ice loads can be explained and ice strengthening can be understood.			
Skills	The challenges and requirements due to ice can be assessed and the accuracy of these assessment can be evaluated. Calculation models to assess ice loads can be used and a structure can be designed accordingly.			
Personal Competence				
Social Competence	Students are capable to present their structural design and discuss their decisions constructively in a group.			
Autonomy	Independent and individual assignment tasks can be carried out and presented whereby the capabilities to both, present and defend, the skills and findings will be achieved.			
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	130 min			
Assignment for the Following Curricula	T I NOVLOTICAT MIOCUANICAT ENVIRONMANTALI OCUNICAT L'OUNDIAMONTALVI L'OULCO, ETOCTIVO L'OUNDITICOLA			

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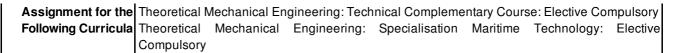
Course L1607: Ice Eng	jineering
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Walter Kuehnlein
Language	DE/EN
Cycle	WiSe
Content	 Ice, Ice Properties, Ice Failure Modes and Challenges and Requirements due to Ice Introduction, what is/means 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 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 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 o cohesive element models for real life structures. Discussion of contribution of ice properties, hydrodynamics and rubble. Ice Design Philosophies and Perspectives What are the main iderences 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 M
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 st	Course L1575: Ship structural design for arctic conditions		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Sören Ehlers, Dr. Rüdiger Ulrich Franz von Bock und Polach		
Language	DE/EN		
Cycle	WiSe		
Content	The structural design under ice loads will be carried out for an individual case		
Literature	FSICR, IACS PC and assorted publications		

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Module M1165: S	Ship Safety			
Courses				
Title		Тур	Hrs/wk	СР
Ship Safety (L1267)		Lecture	2	4
Ship Safety (L1268)		Recitation Section (large)	2	2
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge	Ship Design, Hydrostatics, Statistical Proces	ses		
Educational Objectives	After taking part successfully, students have	reached the following lea	rning resul	ts
Professional Competence				
Knowledge	The student shall lean to integrate safety as the undertsnding and application of existing rules as well as the un is targeted by a rule. Further, methods of demonstrating equivaler	derstanding of the sfatey	concept ar	
	he 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.			
Skills	- Freeboard, water- and weathertight subdivi	sions, openings		
	- all aspects of intact stability, including spec			
	- damage stability for passenger vessels incl	is including Stockholm agreement		
	- damage stbility fopr cargo vessels			
	- on board stability, inclining experiment and	stability booklet		
	- Relevant manoevering information			
Personal Competence				
-	The student learns to take responsibilty for th	e safety of his desiann.		
	Responsible certification of technical design	, .		
	Independent Study Time 124, Study Time in			
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
	Naval Architecture and Ocean Engineering:	Core qualification: Comp	ulsory	



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Course L1267: Ship Sa	ifety
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 stability, inclining experiment and stability booklet - Relevant manoevering information
Literature	- Relevant manoevering information SOLAS, LOAD LINES, CODE ON INTACT STABILITY. Alle IMO, London.

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	

Module M1178: N	lanoeuvrability and Sha	llow Water Ship Hydro	odynamics	
Courses				
Title		Тур	Hrs/wk	СР
Manoeuvrability of Ships (Lecture	2	3
Shallow Water Ship Hydro	dynamics (L1598)	Lecture	2	3
Module Responsible	Prof. Moustafa Abdel-Maksoud			
Admission Requirements	None			
Recommended Previous Knowledge	B.Sc. Schiffbau			
Educational Objectives	After taking part successfully, stu	dents have reached the follow	ing learning resu	ts
Professional Competence				
Knowledge	The students lern the motion equation and how to describe hydrodynamic forces. They'll will be able to develop methods for analysis of manoeuvring behaviour of ships and explaining the Nomoto equation. The students will know the common model tests as well as their assets and drawbacks. Furthermore, the students lern the basics of assessment and prognosis of ship manoeuvrabilit. Basics of characteristics of flows around ships in shallow water regarding ship propulsion and manoeuvrability will be aquired.			
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
	Independent Study Time 124, Stu	udy Time in Lecture 56		
Credit points				
Course achievement				
	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	T LUOULOTICAT MICCUANICAL ENGINGERING, TOCUNICAT COMPTEMENTARY COULDS, ETOCIMO COMPUTEORY			

Course L1597: Manoe	uvrability 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

Course L1598: Shallov	v Water 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

Specialization Numerics and Computer Science

The focus of the specialization "numerics and computer science" is on the acquisition of in-depth knowledge and skills in engineering-related fields of computer science and numerical analysis. This is made possible by modules in the elective area on the topics distributed or efficient algorithms or algorithms of structural mechanics, process automation technology, digital image analysis, pattern recognition and data compression, approximation and stability, machine learning and data mining, matrix algorithms, Numerical Analysis and Real-Time Systems. This cross-sectional technologies are now largely anchored in modern research and development process of mechanical engineering systems established. In addition, subjects in the Technical Supplement Course for TMBMS (according FSPO) are freely selectable.

Courses				
Title		Тур	Hrs/wk	СР
Industrial Process Automa	ation (L0344)	Lecture	2	3
Industrial Process Automa	ation (L0345)	Recitation Section	n (small) 2	3
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	mathematics and optimization methods principles of automata principles of algorithms and data struct programming skills			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	The students can evaluate and assess discrete event systems. They can evaluate properties of processes and explain methods for process analysis. The students can compare methods for process modelling and select an appropriate method for actual problems. They can discuss scheduling methods in the context of actual problems and give a detailed explanation of advantages and disadvantages of different programming methods. The students can relate process automation to methods from robotics and sensor systems as well as to recent topics like 'cyberphysical systems' and 'industry 4.0'.			
Skills	The students are able to develop and model processes and evaluate them accordingly. This involves taking into account optimal scheduling, understanding algorithmic complexity, and implementation using PLCs.			
Personal Competence				
Social Competence	The students work in teams to solve problems.			
Autonomy	The students can reflect their knowledge and document the results of their work.			
Workload in Hours	Independent Study Time 124, Study Time	me in Lecture 56		
A #1. 1.	, , , , , , , , , , , , , , , , , , , ,			

Credit points 6

Course achievement	Compulsory Bonus	Form Excercises	Description
Examination	Written exam		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Compulsory Chemical and Bio Elective Compulsory Chemical and Biopr Compulsory Computer Science: S Electrical Engineer Compulsory Aircraft Systems Eng International Mana Compulsory Mechanical Engineer Mechatronics: Speci Theoretical Mechan Elective Compulsory Theoretical Mechan Process Engineering	process Engineering ocess Engineering: S Specialisation Intellig ing: Specialisation C gineering: Specialisat gement and Engin ering and Management ialisation Intelligent S nical Engineering: S v ical Engineering: Tec g: Specialisation Che	A - General Bioprocess Engineering: Elective g: Specialisation Chemical Process Engineering: Specialisation General Process Engineering: Elective ence Engineering: Elective Compulsory Control and Power Systems Engineering: Elective ion Cabin Systems: Elective Compulsory eering: Specialisation II. Mechatronics: Elective nt: Specialisation Mechatronics: Elective Compulsory systems and Robotics: Elective Compulsory Specialisation Numerics and Computer Science: hnical Complementary Course: Elective Compulsory mical Process Engineering: Elective Compulsory eess Engineering: Elective Compulsory

Course L0344: Industr	ial Process 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 Process Automation					
Тур	Typ Recitation Section (small)				
Hrs/wk					
СР	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				

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Module M1222: Design and Implementation of Software Systems									
Courses									
TitleTypHrs/wkCDesign and Implementation of Software Systems (L1657)Lecture23Design and Implementation of Software Systems (L1658)Practical Course23									
Module Responsible	nsible Prof. Bernd-Christian Renner								
Admission Requirements	None								
	- Imperativ programming languages (C	, Pascal, Fortran or similar)						
Recommended Previous Knowledge	- Simple data types (integer double c	har, boolean), arrays, if-th	en-else, for, wh	ile, procedure					
Educational Objectives	After taking part successfully, students	After taking part successfully, students have reached the following learning results							
Professional									
Competence									
Knowledge	<i>ge</i> Students are able to describe mechatronic systems and define requirements.								
Skills	Students are able to design and implement mechatronic systems. They are able to argue the combination of Hard- and Software and the interfaces.								
Personal									
Competence	Studente are able to work goal ariented in small mixed groups, learning and breadening								
Social Competence	Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities and define task within the team.								
Autonomy	Students are able to solve individually exercises related to this lecture with instructional direction. Students are able to plan, execute and summarize a mechatronic experiment.								
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture 56							
Credit points	6								
Course achievement									
	Written exam								
Examination duration and scale	90 min								
A opignment for the	Mechatronics: Core qualification: Com	-	and Care	utor Colones					
-	Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory								
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory								

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

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



Courses								
Title Pattern Recognition and D	Data Compression (L0128)	Typ Lecture	Hrs/wk 4	CP 6				
Module Responsible	Prof. Rolf-Rainer Grigat							
Admission Requirements	None							
Recommended Previous Knowledge	arithmatica	inear algebra (including PCA, unitary transforms), stochastics and statistics, b rithmetics						
Educational Objectives	After taking part successfully, students	have reached the followir	ng learning resu	lts				
Professional Competence								
	Students can name the basic concepts	of pattern recognition and	d data compress	ion.				
Knowledge	Students are able to discuss logical co and to explain them by means of exam		oncepts coverec	l in the cour				
Skills	Students can apply statistical methods to classification problems in pattern recognition and to prediction in data compression. On a sound theoretical and methodical basis they can analyze characteristic value assignments and classifications and describe data compression and video signal coding. They are able to use highly sophisticated methods and processes of he subject area. Students are capable of assessing different solution approaches in nultidimensional decision-making areas.							
Personal Competence								
Social Competence	k.A.							
Autonomy		Students are capable of identifying problems independently and of solving them scientifically,						
Workload in Hours	Independent Study Time 124, Study Tir	ne in Lecture 56						
Credit points	6							
Course achievement	None							
Examination	Written exam							
Examination duration and scale	T60 Minutes Content of Lecture and materials in Studie							
	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory Information and Communication Systems: Specialisation Communication Systems, Focu Signal Processing: Elective Compulsory Information and Communication Systems: Specialisation Secure and Dependable IT System Focus Software and Signal Processing: Elective Compulsory							
Accomment for the	International Management and Eng	incoring Specialization	II Intermation	Iechnolo				

Following Curricula	Elective Compulsory						
	nternational Management and Engineering: Specialisation II. Electrical Engineering: Elective						
	Compulsory						
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory						
	Mechatronics: Technical Complementary Course: Elective Compulsory						
	Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science:						
	Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory						

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

Module M1182: Technical Elective Course for TMBMS (according to Subject Specific Regulations) Courses

TUHH

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

Courses							
Title		Тур	Hrs/wk	СР			
Machine Learning and Dat Machine Learning and Dat		Lecture Recitation Sectio	2 on (small) 2	4 2			
Module Responsible			_				
Admission							
Requirements	None						
Recommended Previous Knowledge	CalculusStochastics						
Educational Objectives	After taking part successfully,	students have reached the follo	wing learning resu	lts			
Professional							
Competence	• • • • • •	<i>"</i>		, .			
Knowledge	Students can explain the difference between instance-based and model-based learning approaches, and they can enumerate basic machine learning technique for each of the two basic approaches, either on the basis of static data, or on the basis of incrementally incoming data . For dealing with uncertainty, students can describe suitable representation formalisms, and they explain how axioms, features, parameters, or structures used in these formalisms can be learned automatically with different algorithms. Students are also able to sketch different clustering techniques. They depict how the performance of learned classifiers 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.						
Skills	Student derive decision trees and, in turn, propositional rule sets from simple and static data tables and are able to name and 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 mixture learning. They can contrast kNN classifiers, neural networks, and support vector machines, and name their basic application areas and algorithmic properties. Students can describe basic clustering techniques and explain the basic components of those techniques. Students compare related machine learning techniques, e.g., k-means clustering and nearest neighbor classification. They can distinguish various ensemble learning techniques and compare the 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							
Examination							
Examination duration	90 minutes						

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

Course L0340: Machine Learning and Data Mining		
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	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russel, Peter Norvig, Prentice Hall, 2010, Chapters 13, 14, 18-21 Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press 2012 	

Course L0510: Machin	Course 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	



Module M0653: H	ligh-Performance Computin	ng		
Courses				
Title Fundamentals of High-Per	rformance Computing (L0242)	Typ Lecture	Hrs/wk 2	СР 3
Fundamentals of High-Per	rformance Computing (L1416)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Thomas Rung			
Admission Requirements	None			
Recommended Previous Knowledge		modern 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 modern hardware examples. Students can explain the relation between hard- and software aspects for the design of algorithms.			
Skills	Student can perform a critical assessment of the computational efficiency of simulation approaches.			
Personal Competence Social Competence Autonomy	Students are able to develop and code algorithms in a team.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
Examination	Written exam			
Examination duration and scale	1.5h			
-	Naval Architecture and Ocean Engine Theoretical Mechanical Engineerir Elective Compulsory Theoretical Mechanical Engineering:	g: Specialisation Numerics a	and Comp	uter Science

Course L0242: Fundamentals 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: Fundan	urse L1416: Fundamentals of High-Performance Computing	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
CP	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				
Fitle		Тур	Hrs/wk	СР
Approximation and Stability Approximation and Stability		Lecture Recitation Section (small)	3	4 2
Module Responsible	Prof. Marko Lindner			
Admission Requirements	None			
Recommended Previous Knowledge	 Linear Algebra: systems of linear equations, least squares problems, eigenvalues, singular values Analysis: sequences, series, differentiation, integration 			
Educational Objectives	After taking part successfully, stu	dents have reached the following lea	arning resul	lts
Professional Competence				
Knowledge	 Students are able to sketch and interrelate basic concepts of functional analysis (Hilbert space, operators), name and understand concrete approximation methods, name and explain basic stability theorems, discuss spectral quantities, conditions numbers and methods of regularisation 			
Skills	 Students are able to apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities, apply regularisation methods. 			
Personal Competence				
Social Competence	Students are able to solve s appropriately (e.g. as a seminar	pecific problems in groups and presentation).	to present	their resul
Autonomy	 Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. 			
Workload in Hours	Independent Study Time 124, St	udy Time in Lecture 56		
Credit points	6			
Course achievement	Compulsory BonusFormDescriptionYesNonePresentation			
Examination				
Examination duration and scale	20 min			

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

Course L0487: Approx	imation 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
	 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.
Content	 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: 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

TUHH Hamburg University of Technology

Courses				
Title Numerical Mathematics II Numerical Mathematics II		Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3
	Prof. Sabine Le Borne		-	0
Admission Requirements				
Recommended Previous Knowledge	Numerical Mathematics IMATLAB knowledge			
Educational Objectives	After taking part successfully, student	ts have reached the following lea	rning resu	lts
Professional Competence				
Knowledge	 problems, eigenvalue problems, eigenvalue problems, repeat convergence statemer sketch convergence proofs, explain practical aspects of not 	umerical methods concerning rur	ns and exp	olain their core
Skills	 justify the convergence beha and solution algorithm and to for a given problem, development 	re advanced numerical methods viour of numerical methods with transfer it to related problems, op a suitable solution approac thms, to execute this approach a	n respect t h, if nece	o the probler ssary throug
Personal Competence	Students are able to			
Social Competence	 work together in heterogene programs and background k 	eously composed teams (i.e., teanowledge), explain theoretical f ects regarding the implementation	oundation	s and suppo
Autonomy	individually or in a team,	ting theoretical and practical exc gess and, if necessary, to ask que		

Workload in Hours Independent Study Time 124, Study Time in Lecture 56

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	
Examination duration and scale	25 min
Assignment for the Following Curricula	Lechnomathematics: Specialisation L Mathematics: Elective Compulsory

Course L0568: Numer	ical Mathematics II
Тур	Lecture
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	 Error and stability: Notions and estimates Interpolation: Rational and trigonometric interpolation Quadrature: Gaussian quadrature, orthogonal polynomials Linear systems: Perturbation theory of decompositions, structured matrices Eigenvalue problems: LR-, QD-, QR-Algorithmus Krylov space methods: Arnoldi-, Lanczos methods
Literature	 Stoer/Bulirsch: Numerische Mathematik 1, Springer Dahmen, Reusken: Numerik f ür Ingenieure und Naturwissenschaftler, Springer

Course L0569: Numer	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	of. 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	
-	tructural Mechanics (L0284) tructural Mechanics (L0285)	Lecture Recitation Section (sr	2 nall) 2	3 3	
_	Prof. Alexander Düster			0	
Admission Requirements					
-	Knowledge of partial differential equati	ons is recommended.			
Educational Objectives	After taking part successfully, students	have reached the following	learning resu	lts	
Professional Competence					
Knowledge	Students are able to + give an overview of the standard algorithms that are used in finite element programs. + explain the structure and algorithm of finite element programs. + specify problems of numerical algorithms, to identify them in a given situation and to explai their mathematical and computer science background.				
Skills	Students are able to + construct algorithms for given numerical methods. + select for a given problem of structural mechanics a suitable algorithm. + apply numerical algorithms to solve problems of structural mechanics. + implement algorithms in a high-level programming languate (here C++). + critically judge and verfiy numerical algorithms.				
Personal Competence					
Social Competence	Students are able to + solve problems in heterogeneous groups and to document the corresponding results.				
Autonomy	Students are able to + acquire independently knowledge to	solve complex problems.			
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	2h				
_	Materials Science: Specialisation Modeling: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsor Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science Elective Compulsory				

Course L0284: Numer	ical 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	 Motivation Basics of C++ Numerical integration Solution of nonlinear problems Solution of linear equation systems Verification of numerical algorithms 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: Numer	ourse L0285: Numerical Algorithms in Structural Mechanics			
Тур	Typ 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			

Module M12/8. C	compilers for Embedded S	Svetome			
-		Systems			
Courses Title			Tun	Hrs/wk	СР
Compilers for Embedded	Systems (L1692)		Typ Lecture	3	4
Compilers for Embedded	Systems (L1693)		Project-/problem-based Learning	1	2
Module Responsible	Prof. Heiko Falk				
Admission Requirements	None				
Recommended	Module "Embedded Systems"				
	C/C++ Programming skills				
Educational Objectives	After taking part successfully, stude	ents have re	ached the following lea	arning resu	lts
Professional Competence					
Knowledge	 The relevance of embedded systems increases from year to year. Within such systems, the amount of software to be executed on embedded processors grows continuously due to its lower costs and higher flexibility. Because of the particular application areas of embedded systems, highly optimized and application-specific processors are deployed. Such highly specialized processors impose high demands on compilers which have to generate code o highest quality. After the successful attendance of this course, the students are able to illustrate the structure and organization of such compilers, to distinguish and explain intermediate representations of various abstraction levels and to assess optimizations and their underlying problems in all compiler phases. The high demands on compilers for embedded systems make effective code optimizations mandatory. The students learn in particular, which kinds of optimizations are applicable at the source code level, how the translation from source code to assembly code is performed, which kinds of optimizations are applicable at the assembly code level, how memory hierarchies can be exploited effectively. Since compilers for embedded systems often have to optimize for multiple objectives (e.g. average- or worst-case execution time, energy dissipation, code size), the students learn to evaluate the influence of optimizations on these different criteria.				
Skills	After successful completion of the course, students shall be able to translate high-lev program code into machine code. They will be enabled to assess which kind of coc optimization should be applied most effectively at which abstraction level (e.g., source of assembly code) within a compiler. While attending the labs, the students will learn to implement a fully functional compile including optimizations.				
Personal Competence					
Social Competence	Students are able to solve similal accordingly.	r problems	alone or in a group a	nd to prese	ent the resul
	Students are able to acquire new	v knowledg	e from specific literatu	re and to	associate th

Autonomy	knowledge with other classes.					
Workload in Hours	ndependent Study Time 124, Study Time in Lecture 56					
Credit points	6					
Course achievement	None					
Examination						
Examination duration and scale	30 min					
Assignment for the Following Curricula	Mechatronics, Specialisation System Design, Flective Compulsory					

Course L1692: Compil	ers for Embedded Systems
Тур	Lecture
Hrs/wk	3
СР	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. 2nd 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 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	
Mathematical Image Processing (L0991) Mathematical Image Processing (L0992)			Lecture Recitation Section (small)	3 1	4 2	
Module Responsible Prof. Marko Lindner						
Admission						
Requirements	None					
Recommended Previous Knowledge	······································					
Educational Objectives	After taking part succ	essfully, students have	e reached the following lea	rning resu	lts	
Professional						
Competence	Studente ere able to					
Knowledge	 explain methods of image segmentation and registration sketch and interrelate basic concepts of functional analysis 					
o	Students are able to					
Skills	 implement and apply elementary methods of image processing explain and apply modern methods of image processing 					
Personal Competence						
Social Competence	Students are able to work together in heterogeneously composed teams (i.e., teams from different study programs and 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 questions 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 hard problems. 					
Workload in Hours	Independent Study T	me 124, Study Time i	n Lecture 56			
Credit points	6					
Course achievement	None					
Examination						
Examination duration and scale	20 min					
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Electiv Compulsory Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Modeling and Simulation: Elective Compulsory Computational Science and Engineering: Specialisation III. Mathematics: Elective Compulsor Mechatronics: Technical Complementary Course: Elective Compulsory					



TUHH Manual Initialisity of Technolo

Course L0991: Mather	natical 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: Mathem	ourse 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 M0716: H	nerarchical Al	gontinms			
Courses					
Title			Тур	Hrs/wk	СР
Hierarchical Algorithms (L Hierarchical Algorithms (L			Lecture Recitation Section (s	2 small) 2	3 3
Module Responsible		orne	, , , , , , , , , , , , , , , , , , ,	,	
Admission					
Requirements					
Recommended Previous Knowledge	Algebra I +	-	ering students (german or is III for Technomathematic	- ,	alysis & Linea
Educational Objectives	After taking part su	ccessfully, students	have reached the followin	g learning resu	lts
Professional Competence					
Knowledge	 Students are able to name representatives of hierarchical algorithms and list their characteristics 				
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 probler adapted variants. 				
Personal Competence					
	Students are able	to			
Social Competence	 work together in heterogeneously composed teams (i.e., teams from different stud programs and background knowledge), explain theoretical foundations and suppor each other with practical aspects regarding the implementation of algorithms. 				
Autonomy	 Students are capable to assess whether the supporting theoretical and practical excercises are better solved individually or in a team, to work on complex problems over an extended period of time, to assess their individual progess and, if necessary, to ask questions and seek help. 				
Workload in Hours	Independent Study	y Time 124, Study T	me in Lecture 56		
Credit points					
Course achievement					
Examination Examination duration and scale					
Assignment for the	Computational Sci Mathematical Mod	ence and Engineer delling in Engineer	Modeling and Simulation: ing: Specialisation III. Math ing: Theory, Numerics, A Systems (TUHH): Elective	ematics: Electiv pplications: Sp	e Compulsor

Following Curricula	Technomath	ematics: Spe	cialisation I. M	athematics: Elec	tive Compu	lsory		
	Theoretical	Mechanical	Engineering:	Specialisation	Numerics	and	Computer	Science:
	Elective Cor	npulsory						
	Theoretical I	Mechanical E	ngineering: Te	chnical Comple	mentary Co	urse:	Elective Co	mpulsory

Course L0585: Hierard	chical Algorithms
Тур	Lecture
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	 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 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 Digital Image Analysis (L0	126)	Typ Lecture	Hrs/wk 4	CP 6
	Prof. Rolf-Rainer Grigat			
Admission Requirements	None			
Recommended Previous Knowledge	System theory of one-dimensional signals (convolution and correlation, sampling theory, interpolation and decimation, Fourier transform, linear time-invariant systems), linear algebra (Eigenvalue decomposition, SVD), basic stochastics and statistics (expectation values, influence of sample size, correlation and covariance, normal distribution and its parameters), basics of Matlab, basics in optics			
Educational Objectives	After taking part successfully, students	have reached the follow	ving learning resul	ts
Professional Competence				
Knowledge	 Describe imaging processes Depict the physics of sensorics Explain linear and non-linear fi Establish interdisciplinary con context Interpret effects of the most immathematical methods and physical methods and physic	Itering of signals nections in the subject portant classes of imag	-	
Skills	 Students are able to Use highly sophisticated method Identify problems and develop Students can solve simple arithmetic image processing and image analysis Students are able to assess different making areas. Students can undertake a prototypical 	and implement creative al problems relating to systems. nt solution approaches	solutions. the specification a in multidimensic	-
Personal Competence	k.A.			
Social Competence				
Autonomy	Students can solve image analysis tas	ks independently using	the relevant literat	ure.
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture 56		
Credit points				

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

Course L0126: Digital Image Analysis		
Тур	Lecture	
Hrs/wk	4	
СР	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Rolf-Rainer Grigat	
Language	EN	
Cycle	WiSe	
Content	 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, color 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 M1020: N	lumerics of Partial D	Differential Equ	ations		
Courses					
Title Numerics of Partial Differe Numerics of Partial Differe			Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3
	Prof. Sabine Le Borne				
Admission Requirements	None				
Recommended Previous Knowledge	 Mathematik I - IV (for Engineering Students) or Analysis & Linear Algebra I + II for Technomathematicians Numerical mathematics 1 Numerical treatment of ordinary differential equations 				
Educational Objectives	After taking part successful	lly, students have re	ached the following lea	Irning resul	ts
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	Students are capable to formulate solution strategies for given problems involving partia differential equations, to comment on theoretical properties concerning convergence and to implement and test these methods in practice.				
Personal Competence					
Social Competence	Students are able to wor different study programs ar				
Autonomy	 Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. 				
Workload in Hours	Independent Study Time 1	24, Study Time in Le	ecture 56		
Credit points	6				
Course achievement	None				
Examination					
Examination duration and scale	25 min				
_	Computational Science and Engineering: Specialisation Scientific Computing: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science Elective Compulsory				

Course L1247: Numer	ics of Partial Differential Equations
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
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: Numer	ourse L1248: Numerics of Partial Differential Equations		
Тур	Recitation Section (small)		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	NN		
Language	DE/EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title Efficient Algorithms (L012))) Lec	p :ture	Hrs/wk	СР 3
Efficient Algorithms (L120)	-	citation Section (small)		3
Module Responsible	Prof. Siegfried Rump			
Admission Requirements	None			
Recommended Previous Knowledge	Programming in Matlab and/or C Basic knowledge in discrete mathema	tics		
Educational Objectives	After taking part successfully, students have reach		ning resul	ts
Professional Competence				
Competence	The students are able to explain th	ne basic theory	and m	nethods of
Knowledge	network algorithms and in particular their data structures. They are able to analyze the computational behavior and computing time of linear			
Skills	The students are able to analyze complex tasks and can determine possibilities to transform them into networking algorithms. In particula they can efficiently implement basic algorithms and data structures o LP- and network algorithms and identify possible weaknesses. They are able to distinguish between different efficient data structures and are able to use them appropriately.			
Personal Competence				
Social Competence	The students have the skills to solve p and to present the achieved results in a	-		all group
Autonomy	The students are able to retrieve necessary informations from the given literature and to combine them with the topics of the lecture. Throughout the lecture they can check their abilities and knowledge on the basis of given exercises and test questions providing an aid to optimize their learning process.			
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ire 56		
Credit points	6			
Course achievement	None			
Examination				
Examination duration				

Assignment for the	Electrical Er	igineering: Sp	pecialisation M	odeling and Sim	nulation: Ele	ective	Compulsory	/
Following Curricula	Theoretical	Mechanical E	ngineering: Te	chnical Comple	mentary Co	urse:	Elective Co	mpulsory
-	Theoretical	Mechanical	Engineering:	Specialisation	Numerics	and	Computer	Science:
	Elective Cor	npulsory						

Course L0120: Efficient Algorithms			
Тур	Lecture		
Hrs/wk	2		
СР			
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28		
	Prof. Siegfried Rump		
Language			
Cycle	WiSe		
Content	 Linear Programming Data structures Leftist heaps Minimum spanning tree Shortest path Maximum flow NP-hard problems via max-cut 		
Literature	 R. E. Tarjan: Data Structures and Network Algorithms. CBMS 44, Society for Industrial and Applied Mathematics, Philadelphia, PA, 1983. Wesley, 2011 http://algs4.cs.princeton.edu/home/ V. Chvátal, ``Linear Programming'', Freeman, New York, 1983. 		

Course L1207: Efficier	Course L1207: Efficient Algorithms		
Тур	Recitation Section (small)		
Hrs/wk			
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Siegfried Rump		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses		Тур	Hrs/wk	СР
Verification Methods (L012	2)	Lecture	2	3
Verification Methods (L120	8)	Recitation Section (sm	nall) 2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in nur	nerics		
Educational Objectives	After taking part successfully, s	tudents have reached the following	learning resu	lts
Professional Competence				
Knowledge	methods with the goal bounds. For several fur	per knowledge of numerica to compute principally exa ndamental problems they b rrectness of the computed r	ct and acc know algo	curate erro
Skills	The students can devise algorithms for several basic problems which compute rigorous error bounds for the solution and analyze the sensitivity with respect to variation of the input data as well.			
Personal Competence				
		skills to solve problems tog eved results in an appropria		
Autonomy	The students are able to retrieve necessary informations from the given literature and to combine them with the topics of the lecture. Throughout the lecture they can check their abilities and knowledge on the basis of given exercises and test questions providing an aid to optimize their learning process.			
Workload in Hours	Independent Study Time 124, S	Study Time in Lecture 56		
Credit points	6			
Course achievement				
Examination				
Examination duration and scale	30 min			
	Compulsory	ecialisation A - General Bioproc ion Intelligence Engineering: Electiv	-	Ŋ

Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Process Engineering: Specialisation Process Engineering: Elective Compulsory
Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory

Course L0122: Verifica	ation Methods
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe
Content	 Fast and accurate interval arithmetic Error-free transformations Verification methods for linear and nonlinear systems Verification methods for finite integrals Treatment of multiple zeros Automatic differentiation Implementation in Matlab/INTLAB Practical applications
Literature	Neumaier: Interval Methods for Systems of Equations. In: Encyclopedia of Mathematics and its Applications. Cambridge University Press, 1990 S.M. Rump. Verification methods: Rigorous results using floating-point arithmetic. Acta Numerica, 19:287-449, 2010.

Course L1208: Verifica	ourse L1208: Verification Methods		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Siegfried Rump		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses					
litle		Тур	Hrs/wk	СР	
	and Digital Filters (L0446) and Digital Filters (L0447)	Lecture Recitation Section (large)	3 1	4 2	
Module Responsible					
Admission Requirements	None				
Recommended Previous Knowledge	 Mathematics 1-3 Signals and Systems Fundamentals of signal and system theory as well as random processes. Fundamentals of spectral transforms (Fourier series, Fourier transform, Laplace transform) 				
Educational Objectives	After taking part successfully, stuc	lents have reached the following lea	rning resul	ts	
Professional Competence					
Knowledge	The students know and understand basic algorithms of digital signal processing. They are familiar with the spectral transforms of discrete-time signals and are able to describe and analyse signals and systems in time and image domain. They know basic structures of digita filters and can identify and assess important properties including stability. They are aware of the effects caused by quantization of filter coefficients and signals. They are familiar with the basics of adaptive filters. They can perform traditional and parametric methods of spectrum estimation, also taking a limited observation window into account.				
Skills	can choose and parameterize su filters according to the minimur efficient implementation, e.g. bas	nethods of digital signal processing itable filter striuctures. In particular, n mean squared error (MMSE) cr ed on the LMS or RLS algorithm. F spectrum estimation and to take	the can de iterion and urthermore	esign adaptiv d develop a e, the studen	
Personal Competence					
Social Competence	The students can jointly solve spe	ecific problems.			
Autonomy	The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems, software tools, clicker system.				
Workload in Hours	Independent Study Time 124, Stu	dy Time in Lecture 56			
Credit points	6				
Course achievement	None				
	Written exam				
Examination duration and scale	90 min				
	Electrical Engineering: Specialis Compulsory	n Intelligence Engineering: Elective (sation Control and Power System sation Information and Communic	s Enginee	ering: Electiv	

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



Course L0446: Digital	Signal Processing and Digital Filters			
Тур	Lecture			
Hrs/wk				
СР	4			
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42			
Lecturer	Prof. Gerhard Bauch			
Language	EN			
Cycle	WiSe			
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 			
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 Processing and Digital Filters		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Gerhard Bauch	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	



Courses				
Title Soft Computing (L1869)	TypHrs/wkCPLecture46			
Module Responsible	Prof. Karl-Heinz Zimmermann			
Admission Requirements	INONE			
	Bachelor in Computer Science.			
Recommended Previous Knowledge	TRasics in higher mathematics are inevitable like calculus linear algebra draph theory ar			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	Students are able to formalize, compute, and analyze belief networks, alignments sequences, hidden Markov models, phylogenetic tree models, neural networks, and fuz: controllers. In particular, inference and learning in belief networks are important topics that the students should be able to master.			
Skills	Students can apply the relevant algorithms and determine their complexity, and they camake use of the statistics language R.			
Personal				
Competence	Students are able to solve specific problems alone or in a group and to present the res			
Social Competence	accordingly.			
Autonomy	Students are able to acquire new knowledge from newer literature and to associate th acquired knowledge to other fields.			
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	125 min			
-	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technolo Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compuls Theoretical Mechanical Engineering: Specialisation Numerics and Computer Scier Elective Compulsory			

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

Courses					
Title Matrix Algorithms (L0984) Matrix Algorithms (L0985)			Typ Lecture Recitation Section (small)	Hrs/wk	CP 3 3
Module Responsible	Dr. Jone Potor		Recitation Section (small)	2	3
Admission Requirements		Zenike			
Recommended Previous Knowledge	 Mathematics I - III Numerical Mathematics 1/Numerics Basic knowledge of the programming languages Matlab and C 				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	 Students are able to name, state and classify state-of-the-art Krylov subspace methods for the solution of the core problems of the engineering sciences, namely, eigenvalue problems, solution of linear systems, and model reduction; state approaches for the solution of matrix equations (Sylvester, Lyapunov, Riccati). 				
Skills	probler 2. assess domair	apable to ent and assess basic Krylov su ns, linear systems, and model re methods used in modern softwa of applicability; ne approaches learned to new, u	duction; are with respect to comp	outing time	-
Personal Competence					
Social Competence	 form g applica 	o and document joint solutions ir roups to further develop the bility; eam to develop, build, and adva	ideas and transfer th	nem to of	her areas
Autonomy	 assess individu define 	ble to y assess the time and effort of se whether the supporting theoret ially or in a team; est problems for testing and exp their individual progess and, if n	ical and practical exce anding the methods;		
Workload in Hours	Independent S	tudy Time 124, Study Time in Le	ecture 56		
Credit points					
Course achievement					
Examination					
Examination duration and scale	30 min				

Assignment for the Following Curricula Following Curricula

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 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

Module M0629: Intelligent Autonomous Agents and Cognitive Robotics

Courses				
Title		Тур	Hrs/wk	СР
	ents and Cognitive Robotics (L0341) ents and Cognitive Robotics (L0512)	Lecture	2	4 2
		Recitation Section (small)	2	2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Vectors, matrices, Calculus			
Educational Objectives	After taking part successfully, students h	ave reached the following lea	rning resu	lts
Professional				
Competence <i>Knowledge</i>	Students can explain the agent abstract and give details about agent design (g main features of environments. The noti- in terms of decision problems and alg- uncertainty in real-world scenarios, stud- employed as a knowledge representa- settings. In addition, students can d sequential settings, with and with com context, students can describe technique identify techniques for simultaneous lo techniques for achieving desired state decision making in a multi-agent setting functions, voting protocol, and mechanis	goals, utilities, environments) on of adversarial agent cooper- orithms for solving these pro- dents can summarize how Ba- tion and reasoning formalism efine decision making pro- plete access to the state of uses for solving (partially obser- s for measuring the value of i ocalization and mapping, and s. Students can explain cooper- g in term of different types of sm design techniques.	. They car eration can blems. Fo yesian ne n in static cedures ir the enviro rvable) Ma nformation d can exp ordination equilibria,	n describe the be discussed r dealing with tworks can be and dynamic n simple and nment. In this arkov decision . Students can blain planning problems and , social choice
Skills	scenarios. For simplified agent applicati optimization techniques. For those networks/dynamic Bayesian networks Students can also name and apply scenarios. For simple and complex dec policies for concrete settings. In multi finding different equilibria states,e.g., students will apply different voting protoc	applications they can and apply bayesian reasor different sampling techniqu ision making students can co -agent situations students w Nash equilibria. For multi-	also crea ning for si es for sir mpute the rill apply t agent dec	ate Bayesiar mple queries nplified agen best action o echniques fo cision making
Personal				
Competence				
Social Competence	Students are able to discuss their solu English	tions to problems with other	s. They co	ommunicate in
Autonomy	Students are able of checking their und concrete problems	erstanding of complex conce	ots by solv	ing varaints of
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration	90 minutes			
	I			

and scale	
	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
-	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

ourse L0341: Intellige	ent Autonomous Agents and Cognitive Robotics		
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	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, Minima algorithm, alpha-beta pruning, elements of chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environmen probabilities, conditional probabilities, product rule, Bayes rule, full joint probabilit distribution, marginalization, summing out, answering queries, complexity independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference b enumeration), typical-case complexity, pragmatics: reasoning from effect (that can b perceived by an agent) to cause (that cannot be directly perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynami Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases hidden Markov models, Kalman filters, Exact inferences and approximations 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 iteratior MDPs 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, Gibbarc Satterthwaite Impossibility Theorem, Direct mechanisms, incentive compatibility strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected		
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17 Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005 Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoa Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009 		

Course 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 3D Computer Vision (L012 3D Computer Vision (L012		Typ Lecture Recitation Section (smal	Hrs/wk 2	CP 3 3
	Prof. Rolf-Rainer Grigat		<i>i</i> , <i>z</i>	5
Admission	None			
Requirements Recommended Previous Knowledge	 Knowlege of the modules Digital Ir Compression are used in the practic Linear Algebra (including PCA SVI) 	cal task D), nonlinear optimizatio	n (Levenbe	rg-Marquard
Educational Objectives	After taking part successfully, students have	e reached the following le	arning resu	Its
Professional Competence <i>Knowledge</i>		of projective geometry		
	 Students are capable of Implementing an exemplary 3D or version of Using highly sophisticated methods Identifying problems and Developing and implementing creat With assistance from the teacher students areas (modules) Digital Image Analysis Pattern Recognition and Data Compand 3D Computer Vision in practical assignments. 	and procedures of the su ive solution suggestions. are able to link the con		three subje
Personal Competence	Students can collaborate in a small team or			of a system
Autonomy	reconstruct a three-dimensional scene or to evaluate volume data sets. Students are able to solve simple tasks independently with reference to the contents of the lectures and the exercise sets. Students are able to solve detailed problems independently with the aid of the tutorial programming task.			
Workload in Hours	Independent Study Time 124, Study Time ir	Lecture 56		
Credit points				
Course achievement	None			
	Written exam			
Examination duration and scale	60 Minutes, Content of Lecture and materia	ls in StudIP		

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

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

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

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Specialization Product Development and Production

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

Module M0815: P	Product Planning				
Courses					
Title		Тур	Hrs/wk	СР	
Product Planning (L0851)		Project-/problem-based Learning	3	3	
Product Planning Seminar	· (L0853)	Project-/problem-based Learning	2	3	
Module Responsible	Prof. Cornelius Herstatt				
Admission Requirements	None				
Recommended Previous Knowledge	Good basic-knowledge of Business Ad	ministration			
Educational Objectives	After taking part successfully, students I	have reached the following le	earning resu	lts	
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 				
Personal Competence					
Social Competence	 Interact within a team Raise awareness for globabl issues 				
Autonomy	 Gain access to knowledge sources Interpret complex cases Develop presentation skills 				

Workload in Hours Independent Study Time 110, Study Time in Lecture 70

Workload in Hours	Independent Study Time	10, Study Time in Lecture	70
Credit points	6		
	Compulsory Bonus	Form	Description
Course achievement	Yes 20 %	Subject theoretical practical work	and
	Written exam		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Global Technology and Compulsory International Managemen Compulsory Mechanical Engineering a Product Development, I Elective Compulsory Product Development, Compulsory Product Development, Compulsory Theoretical Mechanical E Elective Compulsory	t and Engineering: Specia and Management: Speciali Materials and Production Materials and Productio Materials and Productio Engineering: Specialisation	Compulsory & Entrepreneurship: Core qualification: lisation I. Electives Management: Elective sation Management: Elective Compulsory a: Specialisation Product Development: on: Specialisation Production: Elective on: Specialisation Materials: Elective n Product Development and Production: aplementary Course: Elective Compulsory



ourse L0851: Produc	t Planning		
Тур	Project-/problem-based Learning		
Hrs/wk			
СР	3		
	Independent Study Time 48, Study Time in Lecture 42		
	Prof. Cornelius Herstatt		
Language			
Cycle	WiSe Product Planning Process		
	 This integrated lecture is designed to understand major issues, activities and tools in the context of systematic product planning, a key activity for managing the 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 marke attractively 		
Content	Voluntary presentations in the third hour (articles / case studies) - Guest lectures by researchers		
	- Lecture on Sustainability with frequent reference to current research		
	- Permanent reference to current research		
	Examination:		
	In addition to the written exam at the end of the module, students have to attend the PBI exercises and prepare presentations in groups in order to pass the module. Additionall students have the opportunity to present research papers on a voluntary base. With thes presentations it is possible to gain a bonus of max. 20% for the exam. However, the bonus only valid if the exam is passed without the bonus.		
Literature	Ulrich, K./Eppinger, S.: Product Design and Development, 2nd. Edition, McGraw-Hill 2010		

Course L0853: Produc	ourse L0853: Product Planning Seminar			
Тур	Project-/problem-based Learning			
Hrs/wk	2			
СР	3			
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28			
Lecturer	rof. Cornelius Herstatt			
Language	EN			
Cycle				
Content	Seminar is integrative part of the Module Product Planning (for content see lecture) and can not be choosen independantly			
Literature	see/siehe Vorlesung Produktplanung/Product Planning			

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Module M0867: P	Production Planning & Contr	ol and Digital Ente	erprise			
		_	-			
Courses						
Title		Тур	Hrs/wk	СР		
The Digital Enterprise (L0		Lecture	2	2		
Production Planning and C		Lecture	2	2		
Production Planning and C Exercise: The Digital Enter		Recitation Section Recitation Section	. ,	1		
-				•		
Admission	Prof. Hermann Lödding					
Requirements	None					
Recommended Previous Knowledge	Fundamentals of Production and Quali	ty Management				
Educational Objectives	After taking part successfully, students	have reached the followi	ng learning resu	lts		
Professional Competence						
-	Students can explain the contents of th	e module in detail and ta	ike a critical posi	tion 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 Tim	ne in Lecture 84				
Credit points	6					
Course achievement	None	None				
	Written exam					
Examination duration and scale	180 Minuten					
Assignment for the Following Curricula	TRiomedical Engineering. Specialisation Management and Rusiness Administration					

Course L0932: The Dig	jital Enterprise			
Тур	Lecture			
Hrs/wk				
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: Produc	tion Planning 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: Produc	Course L0930: Production Planning and Control		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	1		
Workload in Hours	ependent 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	Axel Friedewald	
Language		
Cycle		
Content	See interlocking course	
Literature	Siehe korrespondierende Vorlesung See interlocking course	

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Module M1182: T Regulations)	echnical Elective Course for TMBMS (according to Subjec	t Specific
Courses		
Title	Typ Hrs/wk	СР
Module Responsible	Prof. Robert Seifried	
Admission Requirements	None	
Recommended Previous Knowledge	see FSPO	
Educational Objectives	After taking part successfully, students have reached the following learning result	S
Professional Competence <i>Knowledge</i>	see FSPO	
Skills Personal Competence	see FSPO	
Social Competence Autonomy		
Workload in Hours	Depends on choice of courses	
Credit points	6	
Assignment for the Following Curricula		ring: Elective Compulsory gy: Elective mpulsory ter Science



Courses					
Title Integrated Product Devek	opment II (L1254)		Typ Lecture	Hrs/wk 3	СР 3
Integrated Product Develo	opment II (L1255)		Project-/problem-based Learning	2	3
Module Responsible					
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge of I	tegrated product	development and applying CA	AE systems	
Educational Objectives	After taking part succ	ssfully, students h	ave reached the following lea	arning resu	lts
Professional Competence					
Competence	After passing the mo	ule students are a	ble to:		
Knowledge	 explain technical terms of design methodology, describe essential elements of construction management, describe current problems and the current state of research of integrated produc development. 				
Skills	 select and apply proper construction methods for non-standardized solutions of problems as well as adapt new boundary conditions, solve product development problems with the assistance of a workshop base approach, choose and execute appropriate moderation techniques. 				
Personal Competence		ile students are a	ble to:		
Social Competence	 After passing the module students are able to: prepare and lead team meetings and moderation processes, 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, implement the accepted feedback autonomous. 				
Workload in Hours	Independent Study T	ne 110, Study Tin	ne in Lecture 70		
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and scale	KU MINIITAN				
	Aircraft Systems Eng	eering: Specialis ment and Engin	ation Cabin Systems: Elective ation Air Transportation Syste eering: Specialisation II. Pro	ms: Electiv	e Compulsor

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

Course L1254: Integra	ted Product Development II			
Тур	Lecture			
Hrs/wk	3			
СР	3			
Workload in Hours	ndependent 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 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 product development and design management autonomous a			
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 und 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 			

Course L1255: Integra	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		

Module M1143: M	lechanical Design Method	ology		
Courses				
Title Mechanical Design Metho Mechanical Design Metho		Typ Lecture Recitation Section (small	Hrs/wk 3) 1	CP 4 2
Module Responsible	Prof. Josef Schlattmann			
Admission Requirements				
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stude	nts have reached the following lea	arning resul	lts
Professional Competence				
Knowledge	Science-based working on product design considering targeted application of specific produce design techniques			
Skills	Creative handling of processes us product design problems / Appli theoretical aspects.			
Personal Competence				
Social Competence				
Autonomy				
	Independent Study Time 124, Study	/ Time in Lecture 56		
Credit points				
Course achievement				
Examination				
Examination duration and scale	30 min			
Assignment for the Following Curricula	International Management and E Production: Elective Compulsory Mechatronics: Specialisation System Biomedical Engineering: Specialisa Compulsory Biomedical Engineering: Specialisa Compulsory Biomedical Engineering: Specialis Compulsory Biomedical Engineering: Specialis Compulsory Theoretical Mechanical Engineering	m Design: Elective Compulsory ation Artificial Organs and Regene ation Implants and Endoprosthese sation Medical Technology and ation Management and Business	erative Med s: Elective Control Th s Administra	icine: Electiv Compulsory eory: Electiv ation: Electiv

Course L1523: Mecha	nical Design Methodology
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Josef Schlattmann
Language	DE
Cycle	SoSe
Content	 Systematic reflection and analysis of the mechanical design process Process structuring in sections (task, functions, acting principles, design-elements and total construction) as well as levels (working-, controlling-, and deciding-levels) Creativity (basics, methods, practical application in mechatronics) Diverse methods applied as tools (function structure, GALFMOS, AEIOU method, GAMPFT, simulation tools, TRIZ) Evaluation and selection (technical-economical evaluation, preference matrix) Value analysis, cost-benefit analysis Low-noise design of technical products Project monitoring and leading (leading projects / employees, organisation in product development, creating ideas / responsibility and communication) Aesthetic product design (industrial design, colouring, specific examples / exercises)
Literature	 Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 VDI-Richtlinien: 2206; 2221ff



Course L1524: Mecha	nical Design Methodology
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Josef Schlattmann
Language	DE
Cycle	SoSe
Content	 Systematic reflection and analysis of the mechanical design process Process structuring in sections (task, functions, acting principles, design-elements and total construction) as well as levels (working-, controlling-, and deciding-levels) Creativity (basics, methods, practical application in mechatronics) Diverse methods applied as tools (function structure, GALFMOS, AEIOU method, GAMPFT, simulation tools, TRIZ) Evaluation and selection (technical-economical evaluation, preference matrix) Value analysis, cost-benefit analysis Low-noise design of technical products Project monitoring and leading (leading projects / employees, organisation in product development, creating ideas / responsibility and communication) Aesthetic product design (industrial design, colouring, specific examples / exercises)
Literature	 Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 VDI-Richtlinien: 2206; 2221ff



Module M1281: A	Advanced Topics in Vibr	ration		
Courses				
Title		Тур	Hrs/wk	СР
Advanced Topics in Vibra	tion (L1743)	Project-/problem-based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	Vibration Theory			
Educational Objectives	Attor taking part successfully stu	udents have reached the following le	arning resu	Its
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts of Advanced Vibrations and to develop and research new terms and concepts.			
Skills	Students are able to apply existing methods and procesures of Advanced Vibrations and to develop nove methods and procedures.			
Personal Competence				
Social Competence	Students can reach working results	also in groups.		
Autonomy	Students are able to approach giv research tasks by themselves.	ven research tasks individually and to	identify and	follow up nove
Workload in Hours	Independent Study Time 124, St	tudy Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2 Hours			
-	Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production Elective Compulsory			

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

Module M0805: ⁻ Acoustics)	Fechnical Acoustics I (Acoustic Waves, Noise Protection, Psych				
Courses					
Title	Typ Hrs/wk CP				
	oustic Waves, Noise Protection, Psycho Acoustics) Lecture 2 3				
	oustic Waves, Noise Protection, Psycho Acoustics) Recitation Section (large) 2 3				
(L0518) Module Responsible	Prof. Otto von Estorff				
Admission					
Requirements					
Recommended	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematic Dynamics)				
Previous 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 acoustics regarding acoustic waves, noise				
Ű	theoretical and methodical basis.				
Skills	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding methodologies and measurement procedures treated within the module.				
Personal Competence					
Social Competence	Studente een werk in emall groupe en energifie probleme te arrive et joint colutione				
Autonomy	The students are able to independently solve challenging acoustical problems in the area treated within the module. Possible conflicting issues and limitations can be identified and th results are critically scrutinized.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	IYO min				
Assignment for the Following Curricula	Ternolici Develonment, Maleriais and Producijon, Core drainicalion, Elective Compulsorv				

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: Technie	cal Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)
Тур	Recitation Section (large)
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	SoSe
Content	See interlocking course
Literature	See interlocking course

TUHH Hamburg University of Technology

Courses				_		
Title Automation Technology a	nd Systems (L2	329)		Typ Lecture	Hrs/wk 4	CP 4
Automation Technology a	nd Systems (L2	331)		Project-/problem-based Learning	1	1
Automation Technology a	nd Systems (L2	330)		Recitation Section (small)	1	1
Module Responsible	Prof. Thorster	n Schüppstuhl				
Admission Requirements	Nono					
Recommended Previous Knowledge	without major	course assessm	nent			
Educational Objectives	After taking p	art successfully,	students have re	ached the following lea	rning resul	ts
Professional						
Competence	Students					
Knowledge	 know the characteristic components of an automation systems and have good understanding of their interaction know methods for a systematical analysis of automation tasks and are able to use them have special competences in industrial robot based automation systems 					
Skills	 analyz develo design invest created 	ze complex Autor op application ba n subsystems an igate and evalua	ased concepts ar d integrate into c te safety of mach s for robots and	ne system ninery programmable logic co	ntrollers	
Personal						
Competence						
Social Competence	 Students are able to find solutions for automation and handling tasks in groups develop solutions in a production environment with qualified personnel at technical leve and represent decisions. 					
Autonomy	generdevelodesign	ze automation tas ate programs for op solutions for p n safety concepts	robots and prog practice oriented s for automation	rammable logic devices tasks of automation ind	ependently	-
Workload in Hours		Study Time 96, S	Study Time in Leo	ture 84		
Credit points						
• · · ·	Nono					
Course achievement	NUTE					

and scale	
	Product Development, Materials and Production: Specialisation Product Development:
	Elective Compulsory
	Product Development, Materials and Production: Specialisation Production: Compulsory
	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory
	Product Development, Materials and Production: Specialisation Product Development:
Assignment for the	Elective Compulsory
Following Curricula	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Product Development and Production:
	Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Product Development and Production:
	Elective Compulsory

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

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

Course L2330: Automation Technology and Systems		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
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	

TUHH

Courses						
Title Robotics: Modelling and Co	ontrol (L0168) Typ	e	Hrs/wk 3	СР 3		
Robotics: Modelling and Co	ontrol (L1305) Recitat	tion Section (small)	2	3		
Module Responsible	Prof. Uwe Weltin					
Admission Requirements	None					
	Fundamentals of electrical engineering					
Recommended Previous Knowledge	Broad knowledge of mechanics					
	Fundamentals of control theory					
Educational Objectives	After taking part successfully, students have reached	the following lea	rning result	S		
Professional Competence						
Knowledge	Students are able to describe fundamental propertie multiple problems in robotics.					
	Students are able to derive and solve equations of motion for various manipulators.					
OKIIIS						
	Students can design linear and partially nonlinear controllers for robotic manipulators.					
Personal						
Competence	Students are able to work goal-oriented in small mixe	ed arouns				
	Students are able to recognize and improve knowled		endently.			
-	With instructor assistance, students are able to evaluate their own knowledge level and defir a further course of study.					
Workload in Hours	Independent Study Time 110, Study Time in Lecture	70				
Credit points	6					
Course achievement	None					
Examination	Written exam					
and scale	120 min Computer Science: Specialisation Intelligence Engin	pooring: Elective (Compulsor	,		

I	Theoretical Mechanical Engineering: Specialisation Product Development and Production:
	Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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

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

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Courses					
Title Fluidics (L1256)			Typ Lecture	Hrs/wk 2	СР 3
Fluidics (L1371)			Project-/problem-based Learning	1	2
Fluidics (L1257)			Recitation Section (large)	1	1
Module Responsible					
Admission Requirements	None				
Recommended Previous Knowledge	Good knowledge of mer kinetics), fluid mechanics	•	-	ostatics, ki	nematics ar
Educational Objectives	After taking part successfu	ully, students have re	eached the following lea	Irning resu	lts
Professional Competence					
Knowledge	 explain structures and functionalities of hydrostatic, pneumatic, and hydrodynamic components, explain the interaction of hydraulic components in hydraulic systems, explain open and closed loop control of hydraulic systems, describe functioning and applications of hydrodynamic torque converters, brakes and clutches as well as centrifugal pumps 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 applications, perform numerical simulations of hydraulic systems based on abstract problem definitions, select and adapt pump characteristic curves for hydraulic systems dimension hydrodynamic torque converters and brakes for mechanical aggregates. 				
Personal Competence	After passing the module	students are able to			
Social Competence		ent functional context	in groups,		
Autonomy	After passing the module obtain necessary 		nulation.		
	Independent Study Time	124, Study Time in L	ecture 56		
Workload In Hours					

	Yes	None	Attestation	Systeme	
Examination		n			
Examination duration and scale	90				
Assignment for the Following Curricula	Production: I Product De Compulsory Product De Compulsory Product De Compulsory Theoretical Elective Com	I Manageme Elective Com velopment, evelopment, evelopment, Mechanical npulsory	nt and Engined pulsory Materials and Materials and Materials and Engineering: Sp	eering: Specialisation II. Mechatronics: E ering: Specialisation II. Product Developme Production: Specialisation Product Develo Production: Specialisation Production: E Production: Specialisation Materials: E eecialisation Product Development and Prod	nt and opment: Elective Elective fuction:

Course L1256: Fluidice	\$			
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			
	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 interoperation of motor and transmission 			
	Exercise			
Content	 Hydrostatics reading and design of hydraulic diagrams dimensioning of hydrostatic traction and working drives performance calculation 			
1 I				

	Hydrodynamics
	 calculation / dimensioning of hydrodynamic torque converters calculation / dimensioning of centrifugal pumps creating and reading of characteristic curves of pumps and systems
	Field trip
	 field trip to a regional company from the hydraulic industry.
	Exercise
	Numerical simulation of hydrostatic systems
	 getting to know a numerical simulation environment for hydraulic systems transformation of a task into a simulation model simulation of common components variation of simulation parameters using simulations for system dimensioning and optimisation (partly) self-organised teamwork
	Bücher
Literature	 Murrenhoff, H.: Grundlagen der Fluidtechnik - Teil 1: Hydraulik, Shaker Verlag, Aachen, 2011 Murrenhoff, H.: Grundlagen der Fluidtechnik - Teil 2: Pneumatik, Shaker Verlag, Aachen, 2006 Matthies, H.J. Renius, K.Th.: Einführung in die Ölhydraulik, Teubner Verlag, 2006 Beitz, W., Grote, KH.: Dubbel - Taschenbuch für den Maschinenbau, Springer-Verlag, Berlin, aktuelle Auflage
	Skript zur Vorlesung

Course L1371: Fluidice	8
Тур	Project-/problem-based Learning
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Dieter Krause
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1257: Fluidics	\$
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
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

Module M1183: L	aser systems and metho	ds of manufacturing	design and	analysis
Courses				
Title Laser Systems and Proce Methods for Analysing Pro	ess Technologies (L1612) oduction Processes (L0876)	Typ Lecture Lecture	Hrs/wk 2 2	СР 3 3
Module Responsible	Prof. Wolfgang Hintze			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stude	ents have reached the follow	ving learning resu	lts
Professional Competence				
Knowledge Skills				
Personal Competence				
Social Competence Autonomy				
Workload in Hours	Independent Study Time 124, Stud	ly Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Product Development, Materials Elective Compulsory Product Development, Materials and Product Development, Material Compulsory Theoretical Mechanical Engineer Elective Compulsory Theoretical Mechanical Engineering	nd Production: Specialisatio s and Production: Speci ing: Specialisation Product	n Production: Cor cialisation Mater Development ar	npulsory ials: Electiv nd Productior

Course L1612: Laser S	Systems and Process Technologies
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Claus Emmelmann
Language	EN
Cycle	WiSe
Content	 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: Method	ds for 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)

Module M0806: T	echnical Acoustics II (Room Acc	oustics, Computat	ional Me	thods)
Courses				
	oom Acoustics, Computational Methods) (L0519) oom Acoustics, Computational Methods) (L0521)	Typ Lecture Recitation Section (large)	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Previous Knowledge	Technical Acoustics I (Acoustic Waves, Noise Mechanics I (Statics, Mechanics of Materia Dynamics) Mathematics I, II, III (in particular differential e	als) and Mechanics II (H		, Kinematics
Educational Objectives	After taking part successfully, students have i	reached the following lea	rning result	ts
Professional Competence <i>Knowledge</i>	The students possess an in-depth knowled computational methods and are able to give		-	
Skills	methodical basis. The students are capable to handle enginapplication of the demanding computation module.			
Personal Competence				
Social Competence	Students can work in small groups on specifi	c problems to arrive at joi	nt solutions	3.
Autonomy	The students are able to independently solution treated within the module. Possible confliction results are critically scrutinized.		•	
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	20-30 Minuten			
Assignment for the	Aircraft Systems Engineering: Specialisation Mechatronics: Specialisation System Design Product Development, Materials and Product Theoretical Mechanical Engineering: Technic Theoretical Mechanical Engineering: Speci Elective Compulsory	: Elective Compulsory tion: Core qualification: E cal Complementary Cour	lective Con se: Elective	npulsory Compulsory

Course L0519: Technie	cal 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)
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: Technic	cal 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

TUHH

Courses				
Title		Тур	Hrs/wk	СР
Factory Planning (L1445) Production Logistics (L14	46)	Lecture Lecture	3 2	3 3
	Prof. Jochen Kreutzfeldt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor degree in logistics			
Educational Objectives	After taking part successfully, stu	idents have reached the follow	ring learning resu	Its
Professional Competence				
	The students will acquire the foll 1. The students know the latest t		e planning of facto	ories.
Knowledge	2. The students can explain bas procedures while considering di		ng and are able to	o deploy the
	 The students know different r these methods. 	nethods of factory planning an	d are able to dea	l critically w
	The students will acquire the foll 1. The students are able to ana new development and the need	alyze factories and other mate	•	with regard
Skills	2. The students are able to plan	and redesign factories and oth	er material handl	ing systems
	3. The students are able to dem material flow systems.	velop procedures for the imple	ementation of ne	w and revis
Personal Competence				
	The students will acquire the foll 1. The students are able to deve existing material flow systems w	velop plans for the developme	ent of new and ir	nprovement
Social Competence	2. The developed planning prop together.	oosal from the group work can	be documented	and present
	 The students are able to de planning proposals and can ever 			edback on t
	The students will acquire the foll 1. The students can plan and procedures.			sting planni
Autonomy	2. The students can evaluate techniques for factory planning a			
	3. The students are able to carry flow systems.	/ out autonomously new plans	and transformation	ons of mater

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	120 min
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Logistics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory

ourse L1445: Factory	y Planning
	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Jochen Kreutzfeldt
Language	DE
Cycle	WiSe
	The lecture gives an introduction into the planning of factories and material flows. The students will learn process models and methods to plan new factories and improve existing material flow systems. The course includes three basic topics: (1) Analysis of factory and material flow systems (2) Development and re-planning of factory and material flow systems
Content	 (3) Implementation and realization of factory planning 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 factor 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
Literature	 lecture. Bracht, Uwe; Wenzel, Sigrid; Geckler, Dieter (2018): Digitale Fabrik: Methoden und Praxisbeispiele. 2. Aufl.: Springer, Berlin. Helbing, Kurt W. (2010): Handbuch Fabrikprojektierung. Berlin, Heidelberg: Springer Berlin Heidelberg. Lotter, Bruno; Wiendahl, Hans-Peter (2012): Montage in der industriellen Produktion Optimierte Abläufe, rationelle Automatisierung. 2. Aufl.: Springer, Berlin. Müller, Egon; Engelmann, Jörg; Löffler, Thomas; Jörg, Strauch (2009): Energieeffiziente Fabriken planen und betreiben. Berlin, Heidelberg: Springer Berlin Heidelberg.

	3 Independent Study Time 62, Study Time in Lecture 28 DiplIng. Arnd Schirrmann DE
Workload in Hours Lecturer Language	Independent Study Time 62, Study Time in Lecture 28 DiplIng. Arnd Schirrmann DE WiSe • Introduction: situation, significance and main innovation focuses of logistics in production company, aspects of procurement, production, distribution and dispos
Lecturer Language	DiplIng. Arnd Schirrmann DE WiSe • Introduction: situation, significance and main innovation focuses of logistics in production company, aspects of procurement, production, distribution and dispos
Language	DE WiSe • Introduction: situation, significance and main innovation focuses of logistics in production company, aspects of procurement, production, distribution and dispos
	 WiSe Introduction: situation, significance and main innovation focuses of logistics in production company, aspects of procurement, production, distribution and dispose
Cycle	 Introduction: situation, significance and main innovation focuses of logistics in production company, aspects of procurement, production, distribution and dispose
	production company, aspects of procurement, production, distribution and dispos
Content	 Logistics, production and transport networks Logistics as a production strategy: logistics-oriented method of working in a factor throughput time, corporate strategy, structured networking, reducing complexing integrated organization, integrated product and production logistics (IPPL) Logistics-compatible production and process structuring; logistics-compatible produmaterial flow, information and organizational structures Logistics-oriented production control: situation and development tendencies, logistic and cybernetics, market-oriented production planning, control, monitoring, PF systems and production control, cybernetic production organization and controproduction logistics planning: key performance indicators, developing a production logistics concept, computerized aids to planning production logistics, IPPL function economic efficiency of logistics projects Production logistics controlling: production logistics and controlling, material flow oriented cost transparency, cost controlling (process cost accounting, costs model IPPL), process controlling (integrated production system, methods and too MEPOT.net method portal)

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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: P	Polymers			
Courses				
Title Structure and Properties of Processing and design wi		Typ Lecture Lecture	Hrs/wk 2 2	CP 3 3
Module Responsible	Dr. Hans Wittich			
Admission Requirements	None			
Recommended Previous Knowledge	Basics: chemistry / physics / material sc	sience		
Educational Objectives	After taking part successfully, students	have reached the followin	ng learning resul	ts
Professional Competence Knowledge	Students can use the knowledge of plastics and define the necessary testing and analysis. They can explain the complex relationships structure-property relationship and			
Skills	 Students are capable of using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials. selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance. 			
Personal Competence Social Competence	Students can - arrive at funded work results in heterogenius groups and document them.			
Autonomy	Students are able to - assess their own strengths and weaknesses. - assess their own state of learning in specific terms and to define further work steps on this basis. - assess possible consequences of their professional activity.			

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Materials Science: Specialisation Engineering Materials: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L0389: Structu	re and Properties of Polymers
Тур	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: Proces	sing 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	Osswald, Menges: Materials Science of Polymers for Engineers, Hanser Verlag Crawford: Plastics engineering, Pergamon Press Michaeli: Einführung in die Kunststoffverarbeitung, Hanser Verlag Konstruieren mit Kunststoffen, Gunter Erhard , Hanser Verlag

Module M1182: Technical Elective Course for TMBMS (according to Subject Specific Regulations) Courses Title Typ Hrs/wk CP

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Title	Typ Hrs/wk	СР
Module Responsible	Prof. Robert Seifried	
Admission Requirements	None	
Recommended Previous Knowledge	see FSPO	
Educational Objectives	After taking part successfully, students have reached the following learning results	;
Professional Competence		
Knowledge Skills	see FSPO see FSPO	
Personal Competence		
Social Competence Autonomy	see FSPO see FSPO	
Workload in Hours	Depends on choice of courses	
Credit points	6	
Assignment for the Following Curricula		ing: Electiv ompulsory yy: Electiv mpulsory er Science

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Module M1170: P	henomena and Methods in M	laterials Science)	
Courses				
Title	the Characterization of Materials (L1580) formations (L1579)	Typ Lecture Lecture	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in Materials Science, e	e.g. Werkstoffwissensc	haft I/II	
Educational Objectives	After taking part successfully, students h	ave reached the follow	ving learning resul	lts
Professional Competence				
Knowledge	The students will be able to explain the properties of advanced materials along with their			
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science which enables them to select optimum materials combinations depending on the technica 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 v gather new necessary expertise 			
Workload in Hours	Independent Study Time 124, Study Tim	ne in Lecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Product Lavalopment Materials and Production: Specialisation Production; Elective			

Course L1580: Experi	mental 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	Prof. Patrick Huber
Language	DE
Cycle	SoSe
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	equilibria and transformations
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Jörg Weißmüller
Language	DE
Cycle	SoSe
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	Wird im Rahmen der Lehrveranstaltung bekannt gegeben.

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Courses				
Title Structure and properties c Design with fibre-polymer-	of fibre-polymer-composites (L1894) -composites (L1893)	Typ Lecture Lecture	Hrs/wk 2 2	СР 3 3
Module Responsible	Prof. Bodo Fiedler			
Admission Requirements				
Recommended Previous Knowledge	Basics: chemistry / physics / materials s	cience		
Educational Objectives	After taking part successfully, students h	ave reached the follov	ving learning resu	lts
Professional Competence				
	Students can use the knowledge of fib play (fiber / matrix) and define the neces	•	. ,	constituents
Knowledge	They can explain the complex relations the interactions of chemical structure o types, including to explain neighboring	f the polymers, their p	rocessing with the	
Skills	 Students are capable of using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials. approximate sizing using the network theory of the structural elements implement and evaluate. selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance. 			
Personal Competence	Students can			
Social Competence	 arrive at funded work results in heterogenius groups and document them. provide appropriate feedback and handle feedback on their own performanc constructively. 			
	Students are able to - assess their own strengths and weakn	esses.		
Autonomy	 assess their own state of learning in basis. assess possible consequences of their 		define further wor	k steps on t
Workload in Hours	Independent Study Time 124, Study Tin	ne in Lecture 56		
Credit points				
Course achievement				
Examination	Written exam			

Examination duration and scale	
Assignment for the Following Curricula	Elective Compulsory

Course L1894: Structure and properties of fibre-polymer-composites		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Bodo Fiedler	
Language	EN	
Cycle	SoSe	
Content	 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	

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

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Hamburg	Univer	sity of	Techno	logy -

Module M1226: M	lechanical Properties			
	lechanical roperties			
Courses				
Title		Тур	Hrs/wk	СР
Mechanical Behaviour of I	Brittle Materials (L1661)	Typ Lecture	2	3
Dislocation Theory of Plas		Lecture	2	3
Module Responsible	Dr. Frica Lilleodden			
Admission				
Requirements	None			
	Basics in Materials Science I/II			
Previous Knowledge				
Educational Objectives	After taking part successfully, students hav	e reached the followi	ng learning resul	ts
Professional				
Competence				
Knowledge	Students can explain basic principles of cr and thermodynamics (energy minimization			ams, tractions)
Skills	Students are capable of using standardized calculation methods: tensor calculations, derivatives, integrals, tensor transformations			
Personal				
Competence				
Social Competence	Students can provide appropriate feedbac constructively.	ck and handle feedb	ack on their owr	performance
	Students are able to			
	- assess their own strengths and weakness	ses		
Autonomy	 assess their own state of learning in spe basis guided by teachers. 	ecific terms and to de	efine further work	steps on this
	 work independently based on lectures a clarifications when needed 	ind notes to solve pr	oblems, and to a	sk for help or
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Materials Science: Core qualification: Com Mechanical Engineering and Managemen Product Development, Materials and F Elective Compulsory Product Development, Materials and Compulsory Product Development, Materials and Product Theoretical Mechanical Engineering: Spec Theoretical Mechanical Engineering: Tech	t: Specialisation Mate Production: Specialis Production: Special uction: Specialisation stalisation Materials S	sation Product lisation Product Materials: Comp ccience: Elective	Development: tion: Elective ulsory Compulsory



Course L1661: Mecha	nical Behaviour of Brittle Materials
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Gerold Schneider
Language	DE/EN
Cycle	SoSe
	Theoretical Strength Of a perfect crystalline material, theoretical critical shear stress Real strength of brittle materials
	Energy release reate, stress intensity factor, fracture criterion Scattering of strength of brittle materials Defect distribution, strength distribution, Weibull distribution Heterogeneous materials I
Content	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
	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
Literature	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: Disloca	ation Theory of Plasticity	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Erica Lilleodden	
Language	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 and strengthening will be covered along with general principles of creep and strain rate sensitivity. Final topics will include non-FCC dislocations, emphasizing the differences in structure and corresponding implications on dislocation mobility and macroscopic mechanical behavior; and dislocations in finite volumes.	
Literature	Vorlesungsskript Aktuelle Publikationen Bücher: Introduction to Dislocations, by D. Hull and D.J. Bacon Theory of Dislocations, by J.P. Hirth and J. Lothe Physical Metallurgy, by Peter Hassen	

Module M1239: E	experimental Micro- and Nano	mechanics		
Courses				
Title Experimental Micro- and N Experimental Micro- and N		Typ Lecture Recitation Section	Hrs/wk 2 n (small) 1	CP 4 2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Science	cal Properties, Phenc	omena and Method	ds in Materials
Educational Objectives	After taking part successfully students ha	ave reached the follow	ving learning resu	lts
Professional Competence				
Knowledge	Students are able to describe the principles of mechanical behavior (e.g., stress, strain, modulus, strength, hardening, failure, fracture). Students can explain the principles of characterization methods used for investigating microstructure (e.g., scanning electron microscopy, x-ray diffraction)			
Skills	They can describe the fundamental relations between microstructure and mechanical properties. Students are capable of using standardized calculation methods to calculate and evaluate mechanical properties (modulus, strength) of different materials under varying loading states (e.g., uniaxial stress or plane strain).			
Personal Competence				
Social Competence	Students can provide appropriate feedb constructively.	ack and handle feed	lback on their owr	n performance
Autonomy	Students are able to - assess their own strengths and weakne - assess their own state of learning in s basis guided by teachers. - to be able to work independently base for help or clarifications when needed	pecific terms and to o		
	Independent Study Time 138, Study Time	e in Lecture 42		
Credit points				
Course achievement				
Examination Examination duration and scale	60 min			
Assignment for the Following Curricula	Materials Science: Specialisation Nano a Theoretical Mechanical Engineering: Sp Theoretical Mechanical Engineering: Te	ecialisation Materials	Science: Elective	Compulsory

	
	Lecture
Hrs/wk	
СР	
	Independent Study Time 92, Study Time in Lecture 28
	Dr. Erica Lilleodden
Language	
Cycle	SoSe
Content	This class will cover the principles of mechanical testing at the micron and nanometer scale A focus will be made on metallic materials, though issues related to ceramics and polyme materials will also be discussed. Modern methods will be explored, along with the scient 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 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: Loading geometry Governing equations for analysis of stress & strain Case study: Discussion Loading geometry Governing equations for analysis of stress & strain Case study: Discussion Loading geometry Governing equations for analysis of stress & strain Case study: Discussion Loading geometry Governing equations for analysis of stress & strain Case study: Discussion Figure A stress & strain Case study: Figure A stress & strain Case study: Case study: Figure A stress & strain Case study: Case study: Case study: Case study: Case study: Case study: Case study: Case study: Case stu
Literature	Vorlesungsskript Aktuelle Publikationen

Course L1674: Experin	ourse 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	



Courses				
Title Methods in Theoretical M Methods in Theoretical M		Typ Lecture Recitation Sectior	Hrs/wk 2 n (small) 1	CP 4 2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Knowledge of advanced mathemati complex functions, e.g., Mathematic Knowledge of physics, particularly s	s I-IV		equations ar
Educational Objectives	After taking part successfully studer	nts have reached the follow	ring learning resu	lts
Professional Competence				
Competence	The master students will be able to.			
	explain how different modeling methods work.			
	assess the field of application of individual methodological approaches.			
Knowledge	evaluate the strengths and weaknesses of different methods.			
	The students are thereby able to assess which method is best suited to solve a scientific problem and what accuracy can be expected from the simulation results.			
	After completing the module, the stu	dents are able to		
Skills	select the most suitable modeling method as a function of various parameters such a length scale, time scale, temperature, material type, etc			
Personal Competence				
Social Competence	The students are able to discuss c from various fields including physic exhibitions. Further, this promotes th	cs and materials science,	for example at c	onferences
	The students are able to			
	assess their own strengths and weaknesses.			
Autonomy	acquire the knowledge they need	on their own.		
	Independent Study Time 138, Study	Time in Lecture 42		
Credit points				
Course achievement	1			
Examination	I			
Examination duration and scale				

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

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Course L1677: Method	ds in Theoretical Materials Science
Тур	Lecture
Hrs/wk	
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Stefan Müller
Language	DE/EN
Cycle	SoSe
Content	 Introduction Introduction Classification of Modelling Approaches and the Solid State Quantum Mechanical Approaches Electronic states : Atoms, Molecules, Solids Density Functional Theory Spin-Dynamics Thermodynamic Approaches Thermodynamic Potentials Alloys Cluster Expansion 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: Method	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 M1238: C	Quantum Mechanics of So	lids		
Courses				
Title Quantum Mechanics of Se	olide (l. 1675)	Typ Lecture	Hrs/wk 2	CP 4
Quantum Mechanics of S		Recitation Section (—	4
Module Responsible	Prof. Stefan Müller			
Admission Bequirements				
Requirements	None			
Recommended Previous Knowledge	Knowledge of advanced mathemat complex functions, e.g., Mathematic Knowledge of mechanics and phys	cs I-IV		
Educational Objectives	After taking part successfully, stude	nts have reached the followir	ng learning resu	lts
Professional				
Competence	The master students will be able to	explain		
	the basics of quantum mechanics.			
	the importance of quantum physics for the description of materials properties.			
Knowledge				
	The master students will then be able to connect essential materials properties in engineerin with materials properties on the atomistic scale in order to understand these connections.			
	After attending this lecture the students can			
Skills	perform materials design on a qu	antum mechanical basis.		
Personal Competence				
Social Competence	The students are able to discus experts from fields such as physics		chanics-based	subjects w
Autonomy	The students are able to independ They can also acquire the knowled quantum mechanical background fi	ge they need to deal with m		
Workload in Hours	Independent Study Time 138, Study	y Time in Lecture 42		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale				
-	Materials Science: Specialisation N Materials Science: Specialisation M Theoretical Mechanical Engineerin Theoretical Mechanical Engineerin	lodeling: Elective Compulsor g: Specialisation Materials So	y cience: Elective	Compulsory



ourse L1675: Quantu	m Mechanics 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	 Introduction Relevance of Quantum Mechanics Classification of Solids Foundations of Quantum Mechanics Reminder : Elements of Classical Mechanics Motivation for Quantum Mechanics Motivation for Quantum Mechanics Particle-Wave Duality Formalism Elementary QM Problems I Onedimensional Problems of a Particle in a Potential Two-Level System Harmonic Oscillator Electrons in a Magnetic Field Hydrogen Atom Quantum Effects in Condensed Matter Preliminary Electronic Levels Magnetism Superconductivity Squantum Hall Effect
	Physik für Ingenieure, Hering/Martin/Stohrer, Springer
Literature	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 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 Modeling Across The Scales (L1537)			yp ecture	Hrs/wk 2	СР 3
Modeling Across The Scales (L1537) Modeling Across The Scales - Excercise (L1538)			ecitation Section (small)		3
Module Responsible	Prof. Christian Cyron				
Admission Requirements	None				
	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the module Mechanics II and Continuum Mechanics (forces and moments, stress, linear and nonlinea strain, free-body principle, linear and nonlinear constitutive laws, strain energy).				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	The students can describe different deformation mechanisms on different scales and can name the appropriate kind of modeling concept suited for its description.				
Skills	The students are able to predict first estimates of the effective material behavior based on the material's microstructure. They are able to correlate and describe the damage behavior of materials based on their micromechanical behavior. In particular, they are able to apply the knowledge to different problems of material science and evaluate and implement material models into a finite element code.				
Personal Competence					
Social Competence	The students are able to develop solutions, to present them to specialists and to develo ideas further.				
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of scale-bridging modeling and acquire the knowledge required to this end.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and scale	45 min				
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory				



Course L1537: Modeling Across The Scales			
Тур	Typ 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	SoSe		
Content	 modeling of deformation mechanisms in materials at different scales (e.g., molecular dynamics, crystal plasticity, phenomenological models,) relationship between microstructure and macroscopic mechanical material behavior Eshelby problem effective material properties, concept of RVE homogenisation methods, coupling of scales (micro-meso-macro) micromechanical concepts for the description of damage and failure behavior 		
Literature	 D. Gross, T. Seelig, Bruchmechanik: Mit einer Einführung in die Mikromechanik, Springer T. Zohdi, P. Wriggers: An Introduction to Computational Micromechanics D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch G. Gottstein., Physical Foundations of Materials Science, Springer 		



Course L1538: Modeling Across The Scales - Excercise		
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	SoSe	
Content	 modeling of deformation mechanisms in materials at different scales (e.g., molecular dynamics, crystal plasticity, phenomenological models,) relationship between microstructure and macroscopic mechanical material behavior Eshelby problem effective material properties, concept of RVE homogenisation methods, coupling of scales (micro-meso-macro) micromechanical concepts for the description of damage and failure behavior 	
Literature	 D. Gross, T. Seelig, Bruchmechanik: Mit einer Einführung in die Mikromechanik, Springer T. Zohdi, P. Wriggers: An Introduction to Computational Micromechanics D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch G. Gottstein., Physical Foundations of Materials Science, Springer 	



Courses				
Title Advanced Functional Mat	erials (L1625)	Typ Seminar	Hrs/wk 2	CP 6
Module Responsible	Prof. Patrick Huber			
Admission Requirements				
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.g. Materials Science I/II			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional				
Competence	The students will be able to eve	lain the properties of adva	inced materials al	ona with th
Knowledge	The students will be able to explain the properties of advanced materials along with th applications in technology, in particular metallic, ceramic, polymeric, semiconductor, mode composite materials (biomaterials) and nanomaterials.			
Skills	The students will be able to select material configurations according to the technical need and, if necessary, to design new materials considering architectural principles from the micr to the macroscale. The students will also gain an overview on modern materials science which enables them to select optimum materials combinations depending on the technic applications.			
Personal Competence				
Social Competence	The students are able to present s	olutions to specialists and to	o develop ideas fu	rther.
	The students are able to			
Autonomy	assess their own strengthsgather new necessary exp			
Workload in Hours	Independent Study Time 152, Stud	dy Time in Lecture 28		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Materials Science: Core qualificat Mechanical Engineering and Man Biomedical Engineering: Specialis Compulsory Biomedical Engineering: Specialis Biomedical Engineering: Special Compulsory Biomedical Engineering: Special Compulsory Theoretical Mechanical Engineeri Theoretical Mechanical Engineeri	agement: Specialisation Ma sation Artificial Organs and I sation Implants and Endopro isation Medical Technolog sation Management and B	Regenerative Mec ostheses: Elective y and Control Th usiness Administr	licine: Elect Compulsory eory: Elect ation: Elect

Course L1625: Advand	Course L1625: Advanced Functional Materials	
Тур	Seminar	
Hrs/wk	2	
СР	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	 Porous Solids - Preparation, Characterization and Functionalities Fluidics with nanoporous membranes Thermoplastic elastomers Optimization of polymer properties by nanoparticles Fiber composites in automotive Modeling of materials based on quantum mechanics Biomaterials 	
Literature	Wird in der Veranstaltung bekannt gegeben	

Module M1198: N	laterials Physics and Atomist	ic Materials Mod	eling	
Courses				
Title Atomistic Materials Model Materials Physics (L1624)	Typ Lecture Lecture	Hrs/wk 2 2	CP 2 2
	ysics and Modeling (L2002)	Recitation Section	i (smaii) 2	2
Module Responsible Admission Requirements				
Recommended Previous Knowledge	Advanced mathematics, physics and ch	emistry for students in e	engineering or na	tural sciences
Educational Objectives	After taking part successfully, students h	ave reached the follow	ring learning resu	Its
Professional Competence				
Knowledge	The students are able to - explain the fundamentals of condense - describe the fundamentals of the micro optics of materials systems to understand concept and realization to estimate their potential and limitations After attending this lecture the students • can perform calculations regar	of advanced methods is.	in atomistic mode	ling as well as
Skills Personal	 optical properties of condensed are able to transfer their knowle materials design problems. can select appropriate model de are able to further develop simple 	edge to related technol	-	-
Competence Social Competence	The students are able to present solutio	ns to specialists and to	develop ideas fui	ther.
Autonomy	Students are able to assess their kn practice. The students are able to assess thei independently.			
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84		
Credit points	6			
Course achievement	None			
Examination Examination duration	Written exam			
and scale	90 min			

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Course L1672: Atomis	tic Materials Modeling
Тур	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"

ourse L1624: Materia	Ils Physics
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 L2002: Exercis	ses in Materials 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

Courses					
Title Multiscale Materials (L165	9)	Typ Lecture	Hrs∕wk 6	CP 6	
Module Responsible	Prof. Gerold Schneider				
Admission Requirements	None				
Recommended Previous Knowledge	Impetential and an an Advanced methomotics. Evendementals of the theory cleatists				
Educational Objectives	After taking part successfully, students	s have reached the follo	wing learning resu	lts	
Professional Competence					
	The master students will be able to ex	plain			
	the fundamental chemical and phys	sical properties of metals	s, ceramics and po	lymers.	
Knowledge	the correlation of chemical and physical phenomena on the atomic, meso and macroscale and its consequences for the macroscopic properties of materails.				
	The master students will then be able understand the dependence of the macroscopi material properties on the underlying hierarchical levels.				
	After attending this lecture the students can				
Skills	perform materials design for multiscale materials.				
Personal Competence					
Social Competence	The students have an interdisciplinary knowledge of the current state of research in the field multiscale materials. Thus, they can competently discuss with the appropriate target group both with materials scientists, physicists, chemists, mechanical engineers or proce engineers.				
	The students are able to				
Autonomy	assess their own strengths and weaknesses.				
	define tasks independently.				
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84				
Credit points	6				
Course achievement	None				
Examination	Presentation				
Examination duration and scale	90 minutes including discussion, shor	t academic report			
	Materials Science: Core qualification: Theoretical Mechanical Engineering:		s Science: Elective	Compulsory	

urse L1659: Multisc	ale Materials
Тур	Lecture
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Gerold Schneider, Prof. Norbert Huber, Prof. Stefan Müller, Prof. Patrick Huber, Prof. Manfred Eich, Prof. Bodo Fiedler, Dr. Erica Lilleodden, Prof. Karl Schulte, Prof. Jö Weißmüller, Prof. Christian Cyron
Language	DE
Cycle	WiSe
	The materials discussed in this lecture differ from "conventional" ones due to their individu hierarchic microstructure. In conventional microstructure design, the morphology is adjusted for instance, by thermal treatment and concurrent mechanical deformation. The material continually and steadily optimized by small changes in structure or chemical composition, al in combination with self-organization processes (precipitation alloys, ceramic glasses, euted structures). The presented materials consist of functionalized elementary functional units based polymers, ceramics, metals and carbon nanotubes (CNTs), which are used to creat macroscopic hierarchical material systems, whose characteristic lengths range from tt nanometer to the centimeter scale. These elementary functional units are either core-sh
Content	structures or cavities in metals created by alloy corrosion and subsequent polymer filling. Three classes of material systems will be presented: First, hierarchically structured ceramic/metal-polymer material systems similar to natura occurring examples, namely nacre (1 hierarchical level), enamel (3 hierarchical levels) at bone (5 hierarchical levels) will be discussed. Starting with an elementary functional un consisting of ceramic nanoparticles with a polymeric coating, a material is created in which of each hierarchical level, "hard" particles, made of the respective lower hierarchical level, a present in a soft polymer background. The resulting core-shell structure on each hierarchical level is the fundamental difference compared to a compound material made of rig interpenetrating ceramic or metallic networks.
	The second material system is based on nanoporous gold, which acts as a prototypic material for new components in light weight construction with simultaneous actuat properties. Their production and resulting length-scale specific mechanical properties will be explained. Furthermore, related scale-spanning theoretical models for their mechanic behavior will be introduced. This covers the entire scale from the electronic structure on the atomic level up to centimeter-sized macroscopic samples.
	The third material system discussed in the lecture are novel hierarchical nanostructure materials based on thermally stable ceramics and metals for high-temperature photonics we potential use in thermophotovoltaic systems (TPVs) and thermal barrier coatings (TBC Direct and inverted 3D-photonic crystal structures (PhCs) as well as novel optically hyperbo media, in particular, are worthwhile noting. Due to their periodicity and diffraction ind contrast, PhCs exhibit a photonic band structure, characterized by photonic band gaps, are of particularly high photonic densities of states and special dispersion relations. The presented properties are to be used to reflect thermal radiation in TBCs in a strong a directed manner, as well as to link radiation effectively and efficiently in TPVs.
Literature	Aktuelle Publikationen

TUHH

Module M1151: N	laterial Modeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	·			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continuum Mechanics II and Continuum Mechanics (forc strain, free-body principle, linear and nonlinear	es and moments, stres	ss, linear a	
Educational Objectives	After taking part successfully, students have rea	ached the following lear	rning result	3
Professional Competence				
Knowledge	The students can explain the fundamentals of r	nultidimensional consit	utive materi	al laws
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowledge to various problems of material science and evaluate the corresponding material models.			
Personal Competence				
Social Competence	The students are able to develop solutions, ideas further.	to present them to spe	ecialists and	d to develo
Autonomy	The students are able to assess their own strengths and weaknesses. They independently and on their own identify and solve problems in the area of materials mode and acquire the knowledge required to this end.		•	
Workload in Hours	Independent Study Time 124, Study Time in Le	cture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Computational Science and Engineering: S Compulsory Materials Science: Specialisation Modeling: Ele Mechanical Engineering and Management: Sp Biomedical Engineering: Specialisation Artificia Compulsory Biomedical Engineering: Specialisation Implan Biomedical Engineering: Specialisation Medi Compulsory Biomedical Engineering: Specialisation Mana Compulsory Product Development, Materials and Productio	ective Compulsory ecialisation Materials: E al Organs and Regener ts and Endoprostheses cal Technology and C gement and Business	Elective Cor rative Medic Elective C Control The Administra	npulsory cine: Elective ompulsory ory: Elective tion: Elective

Course L1535: Material Modeling		
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	 fundamentals of finite element methods fundamentals of material modeling introduction to numerical implementation of material laws overview of modelling of different classes of materials combination of macroscopic quantities to material microstructure 	
Literature	D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch J. Bonet, R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge G. Gottstein., Physical Foundations of Materials Science, Springer	

Course L1536: Material Modeling		
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Content	 fundamentals of finite element methods fundamentals of material modeling introduction to numerical implementation of material laws overview of modelling of different classes of materials combination of macroscopic quantities to material microstructure 	
Literature	D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch J. Bonet, R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge G. Gottstein., Physical Foundations of Materials Science, Springer	

Supplement Modules

Module M0630: F	lobotics ar	nd Navig	ation in Medici	ne		
Courses						
Title				Тур	Hrs/wk	СР
Robotics and Navigation in				Lecture	2 2	3
Robotics and Navigation in Robotics and Navigation in		,		Project Seminar Recitation Section (small)	-	2 1
Module Responsible						
Admission Requirements	None					
Recommended Previous Knowledge	 principles of math (algebra, analysis/calculus) principles of programming, e.g., in Java or C++ solid R or Matlab skills 					
Educational Objectives	After taking pa	art successfu	Illy, students have re	ached the following lea	rning resul	ts
Professional						
Competence						
Knowledge	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations.					
Skills	The students are able to design and evaluate navigation systems and robotic systems for medical applications.					
Personal Competence						
Social Competence				groups, provide hel	oful feedb	ack and can
Autonomy			their knowledge and ppropriate manner.	d document the results	of their w	ork. They can
Workload in Hours	Independent	Study Time 1	110, Study Time in L	ecture 70		
Credit points	6					
	Compulsory	Bonus	Form	Descriptio	on	
Course achievement		10 %	Written elaboration			
		10 %	Presentation			
	Written exam					
Examination duration and scale	90 minutes					
	Electrical Eng International I Compulsory Mechatronics	ineering: Sp Managemen : Specialisat	ecialisation Medical It and Engineering: S ion Intelligent Syster	Engineering: Elective (Technology: Elective C Specialisation II. Electric ns and Robotics: Electiv ial Organs and Regene	compulsory cal Engine ve Compuls	ering: Elective sory
	I					

Following Curricula	Diamadian. Engine aving: Crasiclication Management and Dusingers Administration. Elective
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Course L0335: Robotics and Navigation 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	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: Robotic	course L0338: Robotics and Navigation in Medicine		
Тур	Typ 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	
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	

Courses			
Title	Тур	Hrs/wk	СР
Air Conditioning (L0594)		3	5
Air Conditioning (L0595)	Recitation Section (la	arge) i	1
Admission	Prof. Gerhard Schmitz		
Requirements	None		
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer		
Educational Objectives	After taking part successfully, students have reached the following	g learning res	ults
Professional Competence			
Knowledge	Students know the different kinds of air conditioning system applications and how these systems are controlled. They are fan of humid air and are able to draw the state changes in a h1+x calculate the minimum airflow needed for hygienic conditions suitable filters. They know the basic flow pattern in rooms and velocity in rooms with the help of simple methods. They know the duct network. They know the different possibilities to produce col processes into suitable thermodynamic diagrams. They know the refrigerants.	niliar with the x-diagram. The in rooms ar are able to c principles to d and are able	change of staney are able nd can choo alculate the calculate and calculate and to draw the
Skills	Students are able to configure air condition systems for buildir They are able to calculate an air duct network and have the abili tasks, regarding natural heat sources and heat sinks. They can into practice. They are able to perform scientific work in the field o	ty to perform s transfer resea	simple plannii Irch knowled
Personal Competence Social Competence	The students are able to discuss in small groups and develop an	approach.	
Autonomy	Students are able to define independently tasks, to get ne knowledge as well as to find ways to use the knowledge in praction	-	e from existi
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points			
Course achievement	None		
Examination	Written exam		
Examination duration	60 min		

Assignment for the Following Curricula	Unternational Management and Engineering: Specialization II. Energy and Environmental
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Course L0594: Air Conditioning		
Тур	Lecture	
Hrs/wk		
СР		
	Independent Study Time 108, Study Time in Lecture 42 Prof. Gerhard Schmitz	
Language		
Cycle		
	1. Overview	
	1.1 Kinds of air conditioning systems	
	1.2 Ventilating	
	1.3 Function of an air condition system	
	2. Thermodynamic processes	
	2.1 Psychrometric chart	
	2.2 Mixer preheater, heater	
	2.3 Cooler	
	2.4 Humidifier	
	2.5 Air conditioning process in a Psychrometric chart	
	2.6 Desiccant assisted air conditioning	
	3. Calculation of heating and cooling loads	
Content	3.1 Heating loads	
	3.2 Cooling loads	
	3.3 Calculation of inner cooling load	
	3.4 Calculation of outer cooling load	
	4. Ventilating systems	
	4.1 Fresh air demand	
	4.2 Air flow in rooms	
	4.3 Calculation of duct systems	
	4.4 Fans	
	4.5 Filters	
	[000]	

	5. Refrigeration systems		
	.1. compression chillers		
	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. Auflage, 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	Prof. Gerhard Schmitz	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0512: Use of Solar Energy

Title		Гур	Hrs/wk	СР
Energy Meteorology (L00 ⁻		_ecture	1	1
Energy Meteorology (L00	I7) F	Recitation Section (small)	1	1
Collector Technology (L00	018) L	ecture	2	2
Solar Power Generation (I	_0015) L	Lecture	2	2
Module Responsible	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended Previous Knowledge	none			
Educational Objectives	After taking part successfully, students have rea	ched the following lea	rning resul	s
Professional Competence				
Knowledge	With the completion of this module, students will be able to deal with technical foundations and current issues and problems in the field of solar energy and explain and evaulate these critically in consideration of the prior curriculum and current subject specific issues. In particular they can professionally describe the processes within a solar cell and explain the specific features of application of solar modules. Furthermore, they can provide an overview of the collector technology in solar thermal systems.			
Skills	Students can apply the acquired theoretical foundations of exemplary energy system using solar radiation. In this context, for example they can assess and evaluate potential and constraints of solar energy systems with respect to different geographical assumptions. The are able to dimension solar energy systems in consideration of technical aspects and give assumptions. Using module-comprehensive knowledge students can evalute the economi and ecologic conditions of these systems. They can select calculation methods within the radiation theory for these topics.			
Personal Competence				
Social Competence	Students are able to discuss issues in the sector addressed within the module.	e thematic fields in	the renew	vable energ
Autonomy	Students can independently exploit sources and acquire the particular knowledge about the subject area with respect to emphasis for the lectures. Furthermore, with the assistance electurers, they can discrete use calculation methods for analysing and dimensioning solar energy systems. Based on this procedure they can concrete assess their specific learning level and can consequently define the further workflow.			
Workload in Hours	Independent Study Time 96, Study Time in Lect	ure 84		
Credit points	6			
Course achievement				
Examination				
Examination duration and scale	3 hours written exam			
	Energy and Environmental Engineering: Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems International Management and Engineering: S	s: Elective Compulsory	,	

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

Course L0016: Energy	Meteorology		
Тур	Lecture		
Hrs/wk			
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	 Introduction: radiation source Sun, Astronomical Foundations, Fundamentals of radiation Structure of the atmosphere Properties and laws of radiation Polarization Radiation quantities Planck's radiation law Wien's displacement law Stefan-Boltzmann law Kirchhoff's law Brightness temperature Absorption, reflection, transmission Radiation balance, global radiation, energy balance Atmospheric extinction Mie and Rayleigh scattering Radiative transfer Optical effects in the atmosphere 		
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 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: Collect	or Technology		
Тур	Lecture		
Hrs/wk			
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. 		



	ower Generation			
Тур	Lecture			
Hrs/wk	2			
СР	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Alf Mews, Martin Schlecht			
Language	DE			
Cycle	SoSe			
Content	 Introduction Primary energy and consumption, available solar energy Physics of the ideal solar cell Light absorption PN junction characteristic values of the solar cell efficiency Physics of the real solar cell Charge carrier recombination characteristics, junction layer recombination, equivale circuit Increasing the efficiency Methods for increasing the quantum yield, and reduction of recombination Straight and tandem structures Hetero-junction, Schottky, electrochemical, MIS and SIS-cell tandem cell Concentrator Concentrator optics and tracking systems Technology and properties: types of solar cells, manufacture, single crystal silicon argallium arsenide, polycrystalline silicon, and silicon thin film cells, thin-film cells of carriers (amorphous silicon, CIS, electrochemical cells) Modules Circuits 			
Literature	 A. Götzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik, Teubn Studienskripten, Stuttgart, 1995 A. Götzberger: Sonnenenergie: Photovoltaik : Physik und Technologie der Solarzel Teubner Stuttgart, 1994 HJ. Lewerenz, H. Jungblut: Photovoltaik, Springer, Berlin, Heidelberg, New Yo 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 Energiewandlur Solarstrahlung, Halbleitereigenschaften und Solarzellenkonzepte, Teubner, Stuttga 1994 R. J. van Overstraeten, R.P. Mertens: Physics, technology and use of photovoltaic Adam Hilger Ltd, Bristol and Boston, 1986 B. O. Seraphin: Solar energy conversion Topics of applied physics V 01 31, Spring: Berlin, Heidelberg, New York, 1995 P. Würfel: Physics of Solar cells, Principles and new concepts, Wiley-VCH, Weinhe 2005 U. Rindelhardt: Photovoltaische Stromversorgung, Teubner-Reihe Umwelt, Stuttg. 2001 V. Quaschning: Regenerative Energiesysteme, Hanser, München, 2003 G. Schmitz: Regenerative Energien, Ringvorlesung TU Hamburg-Harburg 1994/S Institut für Energietechnik 			

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Module M0663: M	larine Geotechnics an	d Numerics			
Courses					
Title		Τ	yp	Hrs/wk	СР
Marine Geotechnics (L054	48)	-	ecture	1	2
Marine Geotechnics (L05-	19)	Re	ecitation Section (large)	2	1
Numerical Methods in Ge	otechnics (L0375)	Le	ecture	3	3
Module Responsible	Prof. Jürgen Grabe				
Admission Requirements	None				
Barrison da d	complete modules: Geotechni	ics I-II, Mathematics	s I-III		
Recommended Previous Knowledge	courses: Soil laboratory course	e			
Educational Objectives	After taking part successfully, s	students have reac	hed the following lea	rning resul	ts
Professional Competence					
Knowledge					
Skills					
Personal					
Competence					
Social Competence					
Autonomy					
Workload in Hours	Independent Study Time 96, S	Study Time in Lectu	ire 84		
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	90 min				
Assignment for the Following Curricula	Civil Engineering: Specialisati Civil Engineering: Specialisati Civil Engineering: Specialisati Theoretical Mechanical Er Compulsory Theoretical Mechanical Engin Water and Environmental Eng Water and Environmental Eng Water and Environmental Eng	ion Structural Engin ion Coastal Engine ngineering: Spec neering: Technical (jineering: Specialis jineering: Specialis	neering: Elective Con eering: Compulsory dalisation Maritime Complementary Cour sation Cities: Elective sation Environment: E	Technolo Se: Elective Compulso Ilective Cor	e Compulsor ry mpulsory

Course L0548: Marine	Geotechnics
Тур	Lecture
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	1	
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28	
Lecturer	Prof. Jürgen Grabe	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0375: Numer	ical Methods in Geotechnics
Тур	Lecture
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Dr. Hans Mathäus Stanford
Language	DE
Cycle	SoSe
Content	Topics: • numerical simulations • numerical algorithms • finite element method • application of finite element method in geomechanics • constitutive models for soils • contact models for soil structure interaction • selected applications
Literature	 Wriggers P. (2001): Nichtlineare Finite-Elemente-Methoden, Springer Verlag, Berlin Bathe Klaus-Jürgen (2002): Finite-Elemente-Methoden. Springer Verlag, Berlin



Courses					
Title	(1.0.407)		Тур	Hrs/wk	СР
Approximation and Stability Approximation and Stability			Lecture Recitation Section (sma	3 I) 1	4 2
Module Responsible					
Admission Requirements	None				
Recommended Previous Knowledge	singular value	 Linear Algebra: systems of linear equations, least squares problems, eigenvalues singular values Analysis: sequences, series, differentiation, integration 			
Educational Objectives	After taking part succ	essfully, students h	ave reached the following le	arning resu	Its
Professional Competence					
Knowledge	 Students are able to sketch and interrelate basic concepts of functional analysis (Hilbert space, operators), name and understand concrete approximation methods, name and explain basic stability theorems, discuss spectral quantities, conditions numbers and methods of regularisation 				
Skills	 Students are able to apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities, apply regularisation methods. 				
Personal Competence					
Social Competence	Students are able appropriately (e.g. as		problems in groups and ation).	to present	their result
Autonomy	 Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. 				
Workload in Hours	Independent Study T	ïme 124, Study Tim	e in Lecture 56		
Credit points	6				
Course achievement	Compulsory BonusYesNone	Form Presentation	Descript	ion	
Examination					
Examination duration	20 min				

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

Course L0487: Approx	imation and Stability		
Тур	Lecture		
Hrs/wk	5		
CP	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. 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 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: 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	



Module M0653: H	ligh-Performance Computi	ng		
Courses				
Title Fundamentals of High-Per	formance Computing (L0242)	Typ Lecture	Hrs/wk 2	СР 3
Fundamentals of High-Per	formance Computing (L1416)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Thomas Rung			
Admission Requirements	None			
Recommended Previous Knowledge	 Basic knowledge in usage of Programming skills 	f modern IT environment		
Educational Objectives	After taking part successfully, studen	ts have reached the following lea	arning resu	Its
Professional Competence				
Knowledge	Students are able to outline the fundamentals of numerical algorithms for high-performance computers by reference to modern hardware examples. Students can explain the relation between hard- and software aspects for the design of algorithms.			
Skills	Student can perform a critical as approaches.	sesment of the computational	efficiency	of simulation
	Students are able to develop and co	de algorithms in a team.		
Autonomy				
	Independent Study Time 124, Study	Time in Lecture 56		
Credit points				
Course achievement				
	Written exam			
Examination duration and scale	1.5h			
-	Naval Architecture and Ocean Engir Theoretical Mechanical Engineeri Elective Compulsory Theoretical Mechanical Engineering	ng: Specialisation Numerics a	and Comp	uter Science

Course L0242: Fundar	nentals 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: Fundan	Irse L1416: Fundamentals of High-Performance Computing		
Тур	Typ Project-/problem-based Learning		
Hrs/wk	2		
CP	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	to Mining (LO240)	Тур	Hrs/wk	СР
Machine Learning and Da Machine Learning and Da		Lecture Recitation Sectio	2 n (small) 2	4 2
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully	students have reached the follow	wing learning resu	ılts
Professional Competence				
Knowledge	approaches, and they can en basic approaches, either on t data . For dealing with uncer and they explain how axiom can be learned automatical different clustering technique improved by ensemble learn	ifference between instance-basin numerate basic machine learnin he basis of static data, or on the tainty, students can describe suits, features, parameters, or struc- ly with different algorithms. Stu s. They depict how the performa- ing, and they can summarize ho r reinforcement learning can also	ng technique for e basis of increment itable representati ctures used in the udents are also a nce of learned cla ow this influences	each of the tw ntally incomin ion formalism ese formalism able to sketw assifiers can b computation
	tables and are able to name apply the basic idea of first-oc EM algorithms for learning algorithms. They also know kNN classifiers, neural net application areas and algo techniques and explain the b machine learning techniques. They can distinguish various of those techniques.	and, in turn, propositional rule and explain basic optimization order inductive leaning. Student parameters of Bayesian netwo how to carry out Gaussian mixi works, and support vector ma prithmic properties. Students asic components of those techn s, e.g., k-means clustering and ensemble learning techniques	n techniques. The s apply the BME, orks and compare ture learning. The achines, and nan can describe ba iques. Students co nearest neighbor	ey present an MAP, ML, an e the differe ey can contra ne their bas asic clusterin ompare relate r classificatio
Personal Competence				
Social Competence				
Autonomy	j			
	Independent Study Time 124	, Study Time in Lecture 56		
Credit points				
Course achievement	l			
	Written exam			
Examination Examination duration and scale				

Assignment for the	Elective Cor	npulsory						
Following Curricula	Theoretical	Mechanical	Engineering:	Specialisation	Numerics	and	Computer	Science:
	Elective Cor	npulsory						
	Theoretical	Mechanical E	ngineering: Te	chnical Comple	mentary Co	urse:	Elective Co	mpulsory

Course L0340: Machin	e Learning and Data Mining
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	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russel, Peter Norvig, Prentice Hall, 2010, Chapters 13, 14, 18-21 Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press 2012

Course L0510: Machin	Course 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				
Fitle Pattern Recognition and D	Data Compression (L0128)	Typ Lecture	Hrs/wk 4	CP 6
Module Responsible	Prof. Rolf-Rainer Grigat			
Admission Requirements	None			
Recommended Previous Knowledge	orithmotion	A, unitary transforms), stocha	stics and sta	tistics, bina
Educational Objectives	After taking part successfully, stud	dents have reached the following	g learning resul	lts
Professional Competence				
	Students can name the basic cor	cepts of pattern recognition and	data compress	sion.
Knowledge	Students are able to discuss logi and to explain them by means of		ncepts covered	l in the cour
Skills	Students can apply statistical me prediction in data compression analyze characteristic value assi and video signal coding. They ar the subject area. Students are multidimensional decision-makin	 On a sound theoretical and ignments and classifications and re able to use highly sophisticate e capable of assessing different 	methodical ba d describe data ed methods and	asis they c compressi d processes
Personal Competence				
Social Competence	k.A.			
Autonomy	Students are capable of identifyin using the methods they have lear		of solving then	n scientifica
Workload in Hours	Independent Study Time 124, Stu	udy Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 Minutes, Content of Lecture a	nd materials in StudIP		
	Computer Science: Specialisatio Electrical Engineering: Speciali Compulsory		unication Syst	ems: Electi
	Information and Communication Signal Processing: Elective Com Information and Communication Focus Software and Signal Proce	pulsory Systems: Specialisation Secure a		

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

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



Courses				
Title		Тур	Hrs/wk	СР
-	tructural Mechanics (L0284) tructural Mechanics (L0285)	Lecture Recitation Section (small	2	3 3
5	Prof. Alexander Düster)	0
Admission Requirements				
•	Knowledge of partial differential equation	ons is recommended.		
Educational Objectives	After taking part successfully, students I	nave reached the following lea	arning resu	Its
Professional Competence				
Knowledge	Students are able to + give an overview of the standard algo + explain the structure and algorithm of + specify problems of numerical algorit their mathematical and computer scient	finite element programs. nms, to identify them in a give		-
Skills	Students are able to + construct algorithms for given numerical methods. + select for a given problem of structural mechanics a suitable algorithm. + apply numerical algorithms to solve problems of structural mechanics. + implement algorithms in a high-level programming languate (here C++). + critically judge and verfiy numerical algorithms.			
Personal Competence				
Social Competence	Students are able to + solve problems in heterogeneous gro	ups and to document the corr	esponding	results.
Autonomy	Students are able to + acquire independently knowledge to	solve complex problems.		
Workload in Hours	Independent Study Time 124, Study Tir	ne in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2h			
-	Materials Science: Specialisation Mode Naval Architecture and Ocean Enginee Technomathematics: Specialisation III. Theoretical Mechanical Engineering: Theoretical Mechanical Engineering Elective Compulsory	ring: Core qualification: Electi Engineering Science: Elective echnical Complementary Cou	Compulso	ry e Compulso

Course L0284: Numer	Course L0284: Numerical Algorithms in Structural Mechanics		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	lependent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Alexander Düster		
Language	DE		
Cycle	SoSe		
Content	 Motivation Basics of C++ Numerical integration Solution of nonlinear problems Solution of linear equation systems Verification of numerical algorithms 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 Algorithms in Structural Mechanics			
Тур	Typ Recitation Section (small)		
Hrs/wk	2		
CP	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		

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Module M0711: N	Numer	ical Mathematics II					
Courses							
Title Numerical Mathematics II Numerical Mathematics II			Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3		
Module Responsible	Prof. Sa	abine Le Borne					
Admission Requirements	None						
Recommended Previous Knowledge		Numerical Mathematics I MATLAB knowledge					
Educational Objectives	Δftor to	After taking part successfully, students have reached the following learning results					
Professional Competence							
Knowledge	•	 Students are able to name advanced numerical methods for interpolation, integration, linear least square problems, eigenvalue problems, nonlinear root finding problems and explain their cor ideas, repeat convergence statements for the numerical methods, sketch convergence proofs, explain practical aspects of numerical methods concerning runtime and storage needs explain aspects regarding the practical implementation of numerical methods wit respect to computational and storage complexity. 					
Skills	 Students are able to implement, apply and compare advanced numerical methods in MATLAB, justify the convergence behaviour of numerical methods with respect to the proble and solution algorithm and to transfer it to related problems, for a given problem, develop a suitable solution approach, if necessary throug composition of several algorithms, to execute this approach and to critically evaluat the results 				o the probler ssary throug		
Personal Competence		ts are able to					
Social Competence	•	work together in beterogeneously composed teams (i.e. teams from different stud					
Autonomy	 Students are capable to assess whether the supporting theoretical and practical excercises are better solved individually or in a team, to assess their individual progess and, if necessary, to ask questions and seek help. 						

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	
Examination duration and scale	25 min
Assignment for the Following Curricula	Lechnomathematics' Shecialisation L Mathematics' Elective Compulsory

Course L0568: Numerical Mathematics II				
Тур	Lecture			
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	 Error and stability: Notions and estimates Interpolation: Rational and trigonometric interpolation Quadrature: Gaussian quadrature, orthogonal polynomials Linear systems: Perturbation theory of decompositions, structured matrices Eigenvalue problems: LR-, QD-, QR-Algorithmus Krylov space methods: Arnoldi-, Lanczos methods 			
Literature	 Stoer/Bulirsch: Numerische Mathematik 1, Springer Dahmen, Reusken: Numerik f ür Ingenieure und Naturwissenschaftler, Springer 			

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		

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Module M0604: H	ligh-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. Alexand	er Düster			-	_
Admission Requirements						
Recommended Previous Knowledge	Knowledge of partial differential equations is recommended.					
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 (h, p, hp) finite element procedures. + explain high-order finite element procedures. + specify problems of finite element procedures, to identify them in a given situation and to explain their mathematical and mechanical background. 					
Skills	Students are able to + apply high-order finite elements to problems of structural mechanics. + select for a given problem of structural mechanics a suitable finite element procedure. + critically judge results of high-order finite elements. + transfer their knowledge of high-order finite elements to new problems.					
Personal						
Competence	Students are able to					
Social Competence	+ solve problems in heterogeneous groups and to document the corresponding results.					
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks.					
Workload in Hours	Independent	Study Time 1	24, Study Time in L	_ecture 56		
Credit points	6					
Course achievement	Compulsory No	Bonus 10 %	Form Presentation	Descriptio Forschend		
Examination	Written exam					
Examination duration and scale						
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory					

Course L0280: High-O	Course L0280: High-Order FEM		
Тур	Lecture		
Hrs/wk	3		
СР	4		
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	Prof. Alexander Düster		
Language	EN		
Cycle	SoSe		
Content	 Introduction Motivation Hierarchic shape functions Mapping functions Computation of element matrices, assembly, constraint enforcement and solution Convergence characteristics Mechanical models and finite elements for thin-walled structures Computation of thin-walled structures Error estimation and hp-adaptivity 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-O	urse 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		

Module M0605: C	computational Structural D	ynamics		
	•	-		
Courses		Tur	l luce hode	0.0
Title Computational Structural I	Dynamics (L0282)	Typ Lecture	Hrs/wk 3	СР 4
Computational Structural I		Recitation Section (small) 1	2
	Prof. Alexander Düster			
Admission Requirements	None			
Recommended Previous Knowledge	Knowledge of partial differential equ	ations is recommended.		
Educational Objectives	After taking part successfully, studen	ts have reached the followir	ng learning resu	lts
Professional				
Competence				
Knowledge	Students are able to + give an overview of the computational procedures for problems of structural dynamics. + explain the application of finite element programs to solve problems of structural dynamics. + specify problems of computational structural dynamics, to identify them in a given situation and to explain their mathematical and mechanical background.			
Skills	Students are able to + model problems of structural dynamics. + select a suitable solution procedure for a given problem of structural dynamics. + apply computational procedures to solve problems of structural dynamics. + verify and critically judge results of computational structural dynamics.			
Personal Competence				
Social Competence	Students are able to + solve problems in heterogeneous	groups and to document the	corresponding	results.
Autonomy	Students are able to + acquire independently knowledge	to solve complex problems.		
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	2h			
Assignment for the Following Curricula	International Management and I Compulsory Materials Science: Specialisation Me Mechatronics: Technical Compleme Naval Architecture and Ocean Engir Theoretical Mechanical Engineering Theoretical Mechanical Engineering	ntary Course: Elective Comp neering: Core qualification: E g: Technical Complementary	y oulsory Elective Compuls Course: Electiv	sory



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

Course 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	

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Module M0657: C	Computational Fluid Dynam	nics II		
Courses				
Title		Тур	Hrs/wk	СР
Computational Fluid Dyna		Lecture	2	3
Computational Fluid Dyna	mics II (L0421)	Recitation Section	(large) 2	3
Module Responsible	Prof. Thomas Rung			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of computational and genera	l thermo/fluid dynamics		
Educational Objectives	After taking part successfully, studen	ts have reached the follow	ing learning resu	ults
Professional Competence				
Knowledge	Establish a thorough understanding of Finite-Volume approaches. Familiarise with details o the theoretical background of complex CFD algorithms.			with details of
Skills	Ability to manage of interface problems and build-up of coding skills. Ability to evaluate assess and benchmark different solution options.			ty to evaluate,
Personal Competence				
Social Competence	Practice of team working during team exercises.			
Autonomy	Indenpendent analysis of specific solution approaches.			
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	0.5h-0.75h			
Assignment for the Following Curricula		eering: Core qualification: : Technical Complementar : Core qualification: Electiv	y Course: Electiv ve Compulsory	ve Compulsory

Course L0237: Compu	Itational 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: Compu	Course L0421: Computational Fluid Dynamics II		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Thomas Rung		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Typ Hrs.wk CP Bieam Generators (L0213) Lecture 3 5 Module Responsible Prof. Alfons Kather	ourses				
Admission Requirements None Recommended Previous Knowledge • "Technical Thermodynamics I and II" • "Heat Transfer" • "Steam Power Plants" Educational Objectives • "Fluid Mechanics" • "Steam Power Plants" Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence The students know the thermodynamic base principles for steam generators and sketch the combus and fuel supply aspects of fossil-fuelled power plants. They can perform thermal de constructive details of the steam generator. The students can describe and evaluate operational behaviour of steam generators and explain these in the context of rel disciplines. The students will be able, using detailed knowledge on the calculation, design, construction of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through prot definition and formalisation, modelling of processes, and training in the solution methodod <i>Skills</i> paralial problems a good overview of this key component of the power plant wil obtained. Within the framework of the exercises the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to life tasks are solved, to highlight aspects of the design of steam generators. Social Competence Especially during the exercises the focus is placed on communication with the tutor. mimates the students to reflect on their existing knowledge and ask specific question turther improve their understanding. Automomp	itle team Generators (L0213	i) Le	ecture	3	5
Technical Thermodynamics I and II"					
Recommended Previous Knowledge • "Heat Transfer" • "Steam Power Plants" • "Steam Power Plants" Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence The students know the thermodynamic base principles for steam generators and sketch the combus and fuel supply aspects of fossil-fuelled power plants. They can perform thermal de constructive details of the steam generators and excluse and evaluate operational behaviour of steam generators and explain these in the context of rel disciplines. The students will be able, using detailed knowledge on the calculation, design, constructive details of the steam generators, and explain these in the context of rel disciplines. Skills The students will be able, using detailed knowledge on the calculation, design, construction of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through prot definition and formalisation, modelling of processes, and training in the solution methodo for partial problems a good overview of this key component of the power plant will obtained. Within the framework of the exercise the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to life tasks are solved, to highlight aspects of the design of steam generators. Social Competence Especially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question further improve their understanding. <	Admission Requirements	None			
Objectives After taking part successfully, students have reached the following learning results Professional Competence The students know the thermodynamic base principles for steam generators and sketch the combus and fuel supply aspects of fossil-fuelled power plants. They can perform thermal de calculations and conceive the water-steam side, as well as they are able to define constructive details of the steam generator. The students can describe and evaluate operational behaviour of steam generators and explain these in the context of rel disciplines. The students will be able, using detailed knowledge on the calculation, design, constructive of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through prot definition and formalisation, modelling of processes, and training in the solution methodo skills Vithin the framework of the exercise the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to life tasks are solved, to highlight aspects of the design of steam generators. Social Competence Especially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question turther improve their understanding. Autonomy The students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from diffe process schemata and boundary conditions are highlighted.		"Heat Transfer""Fluid Mechanics"			
Competence The students know the thermodynamic base principles for steam generators and their ty They are able to describe the basic principles of steam generators and sketch the combus and fuel supply aspects of fossil-fuelled power plants. They can perform thermal de calculations and conceive the water-steam side, as well as they are able to define constructive details of the steam generator. The students can describe and evaluate operational behaviour of steam generators and explain these in the context of rel disciplines. The students will be able, using detailed knowledge on the calculation, design, construction of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through prot botained. Skills Skills Skills Forestonal competence Skills Competence Social Competence Especially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question further improve their understanding. Autonom The students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differ process schemata and boundary conditions are highlighted.		After taking part successfully, students have reac	hed the following lear	rning resul	ts
They are able to describe the basic principles of steam generators and sketch the combust and fuel supply aspects of fossil-fuelled power plants. They can perform thermal de calculations and conceive the water-steam side, as well as they are able to define constructive details of the steam generator. The students can describe and evaluate operational behaviour of steam generators and explain these in the context of rel disciplines. The students will be able, using detailed knowledge on the calculation, design, construction of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through prot definition and formalisation, modelling of processes, and training in the solution methodo <i>Skills</i> for partial problems a good overview of this key component of the power plant will obtained. Within the framework of the exercise the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to life tasks are solved, to highlight aspects of the design of steam generators. Social Competence Especially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question further improve their understanding. Autonomy The students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differences schemata and boundary conditions are highlighted.					
construction of steam generators, linked with a wide theoretical and methodical foundatio understand the main design and construction aspects of steam generators. Through prot definition and formalisation, modelling of processes, and training in the solution methodo for partial problems a good overview of this key component of the power plant will obtained.SkillsWithin the framework of the exercise the students obtain the ability to draw the balances, design the steam generator and its components. For this purpose small but close to life tasks are solved, to highlight aspects of the design of steam generators.Personal CompetenceEspecially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question further improve their understanding.AutonomyThe students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differ process schemata and boundary conditions are highlighted.Workload in HoursIndependent Study Time 124, Study Time in Lecture 56	Knowledge	constructive details of the steam generator. The students can describe and evaluate the operational behaviour of steam generators and explain these in the context of related			
design the steam generator and its components. For this purpose small but close to life tasks are solved, to highlight aspects of the design of steam generators. Personal Competence Social Competence Social Competence Autonomy The students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differences schemata and boundary conditions are highlighted. Workload in Hours Independent Study Time 124, Study Time in Lecture 56	Skills	construction of steam generators, linked with a w understand the main design and construction as definition and formalisation, modelling of proces for partial problems a good overview of this	vide theoretical and m spects of steam gene ses, and training in th	nethodical rators. Thr ne solution	foundation, ough proble methodolo
CompetenceEspecially during the exercises the focus is placed on communication with the tutor. animates the students to reflect on their existing knowledge and ask specific question further improve their understanding.Social CompetenceThe students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differ process schemata and boundary conditions are highlighted.Workload in HoursIndependent Study Time 124, Study Time in Lecture 56		design the steam generator and its component	s. For this purpose s	mall but cl	
Social Competence animates the students to reflect on their existing knowledge and ask specific question further improve their understanding. Autonomy The students will be able to perform basic calculations covering aspects of the st generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differences schemata and boundary conditions are highlighted. Workload in Hours Independent Study Time 124, Study Time in Lecture 56			load as service of		
Autonomy generator, with only the help of smaller clues, on their own. This way the theoretical practical knowledge from the lecture is consolidated and the potential effects from differences schemata and boundary conditions are highlighted. Workload in Hours Independent Study Time 124, Study Time in Lecture 56	Social Competence	animates the students to reflect on their existin			
	Autonomy	generator, with only the help of smaller clues, practical knowledge from the lecture is consoli	on their own. This v dated and the potent	way the th	eoretical a
Credit points 6	Workload in Hours	Independent Study Time 124, Study Time in Lect	ture 56		
	Credit points	6			



Course achievement	No	5 %	Excercises	Aufgabe (in ca. 5 min lösbar) zur Vorlesung der Vorwoche gestellt. Die Antworten müssen üblicherweise als Freitext gegeben werden, aber auch Zeichnungen, Stichpunkte oder, in seltenen Fällen, Multiple Choice sind möglich.
Examination	Written exam			
Examination duration and scale	120 min			
-	Compulsory Energy Syster Energy Syster International Engineering: Theoretical M	ms: Specialis ms: Specialis Managemen Elective Com echanical Er	ation Energy Systems: Elective ation Marine Engineering: Elec t and Engineering: Specialisa pulsory gineering: Specialisation Energ	

Course L0213: Steam	Generators		
Тур	Lecture		
Hrs/wk	3		
СР	5		
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42		
Lecturer	Prof. Alfons Kather		
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, Barberton, Ohio, USA, 1992 		

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

Madula M0549, 5	Dia ala atra magnatian		d Application		
-	Bioelectromagnetics	: Principles an		15	
			True	Line hult	0.0
Title Bioelectromagnetics: Prin	ciples and Applications (L0371))	Typ Lecture	Hrs/wk 3	CP 5
-	ciples and Applications (L0373)		Recitation Section (s	small) 2	1
Module Responsible	Prof. Christian Schuster				
Admission Requirements	NONG				
Recommended Previous Knowledge					
Educational Objectives	After taking hart successful	lly, students have re	ached the following	g learning resul	ts
Professional					
Competence		asic principles rola	tionships and mot	thods of bioglas	tromagnetic
Knowledge	Students can explain the basic principles, relationships, and methods of bioelectromagnetics i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.				
Skills	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to electromagnetic fields for their predictions. They are able to evaluate the effects o electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.				
Personal Competence					
Social Competence	Students are able to work present their results effective	-			ey are able
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English.				
Workload in Hours	Independent Study Time 1	10, Study Time in Le	ecture 70		
Credit points		,,			
Course achievement	Compulsory Bonus	Form Presentation	Desci	ription	



Examination	Oral exam
Examination duration and scale	143 (0)0
Assignment for the Following Curricula	Biomedical Engineering, Specialisation implants and Engobrostheses, Elective Compulsory

Course L0371: Bioelec	ctromagnetics: Principles and Applications		
Тур	Lecture		
Hrs/wk	3		
СР	5		
	Independent Study Time 108, Study Time in Lecture 42		
	Prof. Christian Schuster		
Language			
Cycle	- Fundamental properties of electromagnetic fields (phenomena)		
	- Mathematical description of electromagnetic fields (Maxwell's Equations)		
	- Electromagnetic properties of biological tissue		
	- Principles of energy absorption in biological tissue, dosimetry		
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)		
	- Measurement techniques for characterization of electromagnetic fields		
	- Behavior of electromagnetic fields of low frequency in biological tissue		
Content	- Behavior of electromagnetic fields of medium frequency in biological tissue		
	- Behavior of electromagnetic fields of high frequency in biological tissue		
	- Behavior of electromagnetic fields of very high frequency in biological tissue		
	Diagnostic applications of electromagnetic fields in medical technology		
	Therapeutic applications of electromagnetic fields in medical technology		
	- The human body as a generator of electromagnetic fields		
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)		
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)		
Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)		
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)		

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



Courses				
Title Medical Imaging Systems	(L0819)	Typ Lecture	Hrs/wk 4	CP 6
Module Responsible	Dr. Michael Grass			
Admission Requirements	None			
Recommended Previous Knowledge	none			
Educational Objectives	After taking part successfully, student	s have reached the follow	ving learning resu	lts
Professional Competence				
Knowledge	 Students can: Describe the system configure systems; Explain how the system comfunction; Explain and apply the physical fundamental physical equation Name and describe the physical Explain how spatial and the characterize the images gene Explain which image reconstruction Describe and explain the main clinical Students are able to: 	ponents and the overall I processes that make in ns; cal effects required to gen emporal resolution can rated; uction methods are used	system of the ima naging possible an nerate image contr n be influenced to generate image	aging systen nd use with th rasts; and how
Skills	 Explain the physical process mathematical or physical equations; Calculate the parametric physical equations; Determine the influent temporal resolution of Explain the importance applications; Select a suitable imaging system for a suitable suitable imaging system for a suitable imaging system for a	ations required; eters of imaging system ce of different system of imaging systems; e of different imaging s	ns using the ma	athematical ne spatial ar
Personal				
Competence				
Social Competence				
Autonomy	 Students can: Understand which physical eff Decide independently for which 			e used.
Workload in Hours	Independent Study Time 124, Study 1	ime in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Writton over			

and scale	
Assignment for the Following Curricula	COMPUTEOR/

Course L0819: Medical Imaging Systems			
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. 		

ourses					
itle combined Heat and Power combined Heat and Power			Typ Lecture Recitation Section (la	Hrs/wk 3 arge) 1	CP 5 1
Module Responsible	Prof. Alfons Kathe	r			
Admission Requirements	None				
Recommended Previous Knowledge			nd II"		
Educational Objectives	After taking part s	uccessfully, students h	nave reached the following	g learning resu	lts
Professional Competence					
Knowledge	they can describe the behaviour of premixed flames and non-premixed flames, in order to describe the fundamentals of furnace design in gas-, oil- and coal combustion plant. The students are furthermore able to describe the formation of NO _x and the primary NO _x reduction measures, and evaluate the impact of regulations and allowable limit levels. The students present the layout, design and operation of Combined Heat and Power plants and are in a position to compare with each other district heating plants with back-pressure steam turbine or condensing turbine with pressure-controlled extraction tapping, CHP plants with gas turbine or with combined steam and gas turbine, or even district heating plants with an internal combustion engine. They can explain and analyse aspects of combined heat power and cooling (CCHP) and describe the layout of the key components needed. Through this specialised knowledge they are able to evaluate the ecological significance of district CHP generation, as well as its economics.				
Skills	able to determin processes during gaseous, liquid a exhaust gases. I (combustion) to p both procedures taken from the pr heating network o plants with simulta Within the framew	ne interdisciplinary of combustion. This the nd solid fuels and de n this module the fi provide usable energy enables the students caxis, such as the CH of Hamburg will be us aneous heat extraction pork of the exercises the	I considering the reaction correlations between the en enables quantitative a termination of the quantit rst step toward the utilit y (electricity and heat) is to holistically consider IP energy supply facility ed, to highlight the potent n. the students will first learn the esses. Moreover, the st	ermodynamic nalysis of the les and concer sation of an e taught. An und energy utilisati of the TUHH a ial from electric to calculate the	and chemic combustion ntrations of the energy source derstanding ion. Example and the distri- city generation energetic ar
			sses by the calculation of	-	
Competence					
	Especially during the exercises the focus is placed on communication with the tutor. This animates the students to reflect on their existing knowledge and ask specific questions for improving further this knowledge level.				

Autonomy manner the theoretical and practical knowledge from the lecture is consolidated and the potential impact of different process arrangements and boundary conditions highlighted.

TUHH

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	Credit points 6				
Course achievement	Compulsory Bonus	Form Written elaboration	Description Am Ende jeder Vorlesung wird schriftlich eine zu auswertende Kurzfrage (5-10 min) zu der Vorlesung der Vorwoche gestellt. In den Kurzfragen werden kleine Rechenaufgaben, Skizzen oder auch kleine Freitexte zur Beantwortung gestellt.		
	Written exam				
Examination duration and scale	120 min	120 min			
-	Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				

Тур	Lecture
Hrs/wk	3
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Alfons Kather
Language	DE
Cycle	SoSe
Content	 The subject area of "Combined Heat and Power" covers the following themes: Layout, design and operation of Combined Heat and Power plants District heating plants with back-pressure steam turbine and condensing turbine w 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 Combustion of gaseous fuels Combustion of gaseous fuels Combustion folid 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 Verl 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-chemisc 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	Prof. Alfons Kather	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0771: F	light Physics			
Courses				
Title Aerodynamics and Flight I Flight Mechanics II (L073) Flight Mechanics II (L073)))	Typ Lecture Lecture Recitation Section (large)	Hrs/wk 3 2 1	CP 3 2 1
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None			
Recommended Previous Knowledge	 Basic knowledge in: Mathematics Mechanics Thermodynamics Aviation 			
Educational Objectives	After taking part successfully, stude	nts have reached the following lea	rning resu	lts
Professional Competence Knowledge Skills				
Personal Competence Social Competence Autonomy				
	Independent Study Time 96, Study	Time in Lecture 84		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration and scale	120 Minutes (WS) + 90 Minutes (SS	3)		
Assignment for the Following Curricula	Aircraft Systems Engineering: Core International Management and E Compulsory Product Development, Materials Elective Compulsory Product Development, Materials Compulsory Product Development, Materials Compulsory Theoretical Mechanical Engineerin Compulsory Theoretical Mechanical Engineerin	ngineering: Specialisation II. Avi and Production: Specialisation and Production: Specialisatio and Production: Specialisati ng: Specialisation Aircraft System	Product n Produc on Mater ns Enginee	Developmen tion: Elective ials: Elective ering: Elective

Course L0727: Aerody	namics 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 Mechanics II					
Тур	Lecture				
Hrs/wk	2				
СР					
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28				
Lecturer	Prof. Frank Thielecke, Mike Montel				
Language	DE				
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 Mechanics II			
Тур	Typ Recitation Section (large)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Frank Thielecke, Mike Montel		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title Aircraft Systems II (L0736	S) L	Fyp Lecture	Hrs/wk	CP 4
Aircraft Systems II (L074)	·	Recitation Section (large)	2	2
Admission	Prof. Frank Thielecke			
Requirements	None			
Recommended Previous Knowledge	 basic knowledge of: mathematics mechanics thermo dynamics electronics fluid technology control technology 			
Educational Objectives	After taking part successfully, students have rea	ched the following lea	rning resul	ts
Professional				
Competence	Students are able to			
Knowledge	 describe the structure of primary flight of fuel- and landing gear-systems in gen applications. explain different configurations and des explain atmospheric conditions for icing 	eral along with corres	sponding p	properties and
Skills	 Students are able to size primary flight control actuation syste perform a controller design process for the design high-lift kinematics design and analyse landing gear system design anti-ice systems 	he flight control actuate	ors	
Personal Competence				
Competence	Students are able to:			
Social Competence				
	Students are able to:			
Autonomy	 derive requirements and perform app aircraft systems from complex issues and 		-	
Workload in Hours	Independent Study Time 110, Study Time in Leo	cture 70		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	165 Minutes			
	Aircraft Systems Engineering: Core qualification	Compulsory		

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

Course L0736: Aircraf	t Systems II				
Тур	Lecture				
Hrs/wk					
СР					
Workload in Hours	dependent 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: Aircraft Systems II				
Тур	Recitation Section (large)			
Hrs/wk	2			
СР	2			
Workload in Hours	dependent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Frank Thielecke			
Language	DE			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M0860: Harbour Engineering and Harbour Planning

Courses				
Title		Тур	Hrs/wk	СР
Harbour Engineering (L0809)		Lecture	2	2
Harbour Engineering (L14	.14)	Project-/problem-based Learning	1	2
Port Planning and Port Co	nstruction (L0378)	Lecture	2	2
Module Responsible	Prof. Peter Fröhle			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of coastal engineering			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	design of a part and apply them to design teaks. They can design the fundamental elements			
Skills	The students are able to select and apply appropriate approaches for the functional design of ports.			
Personal Competence				
Social Competence	The students are able to deploy their gained knowledge in applied problems such as the functional design of ports. Additionaly, they will be able to work in team with engineers of other disciplines.			
Autonomy	The students will be able to independently extend their knowledge and apply it to new problems.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
	The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks.			
Assignment for the Following Curricula	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Compulsory Civil Engineering: Specialisation Water and Traffic: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			



Course L0809: Harbou	r 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 Engineering				
Тур	oject-/problem-based Learning			
Hrs/wk				
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			

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	 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

Module M1021: M	larine Diesel E	ingine Plants			
Courses					
Title			Тур	Hrs/wk	СР
Marine Diesel Engine Plants (L0637)			Lecture Recitation Section	3	4 2
Marine Diesel Engine Plan			Recitation Section	(large) i	2
•	Prof. Christopher Friedrich Wirz				
Admission Requirements	None				
Recommended Previous Knowledge					
Educational Objectives	After taking part suc	ccessfully, students	have reached the follow	ing learning resu	Its
Professional Competence					
-	Students can				
	• explain different ty	ypes four / two-strok	e engines and assign ty	pes to given enai	nes,
Knowledge	• name definitions a	and characteristics	as well as		
	 name definitions and characteristics, as well as elaborate on special features of the heavy oil operation, lubrication and cooling. 				
	Students can				
	• evaluate the interaction of ship, engine and propeller,				
Skills	• use relationships between gas exchange, flushing, air demand, charge injection and combustion for the design of systems,				
	• design waste heat recovery, starting systems, controls, automation, foundation and design machinery spaces , and				
	 apply evaluation methods for excited motor noise and vibration. 				
Personal Competence					
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.				
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.				
Workload in Hours	Independent Study	Time 124, Study Ti	me in Lecture 56		
Credit points		-			
Course achievement					
Examination	Oral exam				
Examination duration and scale	120 min				
-	Energy Systems: Specialisation Energy Systems: Elective Compulsory Energy Systems: Specialisation Marine Engineering: Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory				



Course L0637: Marine	Diesel Engine Plants				
Тур	Lecture				
Hrs/wk					
СР					
Workload in Hours	dependent Study Time 78, Study Time in Lecture 42				
Lecturer	of. 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 Engine Plants		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	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	

Module M1133: P	Port Logistics					
Courses						
Title Port Logistics (L0686) Port Logistics (L1473)		Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3		
Module Responsible	Prof. Carlos Jahn					
Admission Requirements	NONO					
Recommended Previous Knowledge	nono					
Educational Objectives	Attar taking part successfully students hav	e reached the following lea	rning resul	ts		
Professional Competence						
Knowledge	 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 the relevant operator models) and place them in their historical context; explain and evaluate different types of seaport terminals and their specific characteristics (cargo, transhipment technologies, logistic functional areas); analyze common planning tasks (e.g. berth planning, stowage planning, yard planning) at seaport terminals and develop suitable approaches (in terms of methods and tools) to solve these planning tasks; identify future developments and trends regarding the planning and control of innovative seaport terminals and discuss them in a problem-oriented manner. 					
Skills	 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, equipment requirements, quay wall length, port access) or selected terminal types; reliably estimate which boundary conditions influence common logistics indicators in the static planning of selected terminal types and to what extent. 					
Personal Competence Social Competence	After completing the module, students can. transfer the acquired knowledge to discuss and successfully organize 	further questions of port log extensive task packages in results in writing in an ur	small grou	•		
	After completing the module, the students a	are able to				
	[000]					

Autonomy	 research and select specialist literature, including standards, guidelines and journal papers, and to develop the contents independently; submit own parts in an extensive written elaboration in small groups in due time and to present them jointly within a fixed time frame. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory BonusFormDescriptionNo15 %Written elaboration			
Examination	Written exam			
Examination duration and scale	120 minutes			
Assignment for the Following Curricula	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory	/e /e		

ourse L0686: Port Lo					
Hrs/wk CP					
	ndependent Study Time 62, Study Time in Lecture 28 Prof. Carlos Jahn				
Language Cycle					
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 nside 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 internationale 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 Logistic: Management. Woitschützke, Claus-Peter (2013). Verkehrsgeografie. 				

Course L1473: Port Lo	gistics			
Тур	Recitation Section (small)			
Hrs/wk				
CP	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							
Fitle Maritime Transport (L006 Maritime Transport (L006			Typ Lecture Recitation Section (Hrs 2 small) 2	/wk	CP 3 3	
Module Responsible	,					0	
Admission Requirements							
Recommended Previous Knowledge							
Educational Objectives	After taking part suc	cessfully, students h	ave reached the followin	ng learning	g resul	ts	
Professional Competence	The students are ab	la ta					
Knowledge	 present the actors involved in the maritime transport chain with regard to their typica tasks; name common cargo types in shipping and classify cargo to the corresponding categories; explain operating forms in maritime shipping, transport options and management in transport networks; weigh the advantages and disadvantages of the various modes of hinterland transpor and apply them in practice; present relevant factors for the location planning of ports and seaport terminals and discuss them in a problem-oriented way; estimate the potential of digitisation in maritime shipping. 						
Skills	 supply chair identify pos proposals fo record, map logistics cha perform risk analyse acc everyday life deal with cu way; apply differe 	ne mode of transpo sible cost drivers r cost reduction; and systematically in, identify possible assessments of hum idents in the field o e; urrent research topic	rt, actors and functions in a transport chain analyse material and ir problems and recommen an disruptions to the su f maritime logistics and cs in the field of maritin g methods in a hitherto u ges.	and recor oformation nd solution oply chain evaluating ne logistic	nmeno flows ns; ; g their s in a	d appropria of a maritin relevance differentiate	
Personal Competence	The students are ab	lo to					
Social Competence			work packages in group rated results.	S;			
	The students are ca	pable to					

Compulsory

Module Manual M.Sc.	"Theoretical Mechanical	Engineering"	Hamburg University of Technology
	 submit own share 	s in an extensive written elal	poration in small groups in due time.
Workload in Hours	Independent Study Time	124, Study Time in Lecture 5	6
Credit points	6		
	Compulsory Bonus	Form	Description
Course achievement	No 15 %	Subject theoretical practical work	Teilnahme an einem Planspiel und anschließende schriftliche Ausarbeitung
	Written exam		
Examination duration and scale	120 minutes		
Assignment for the Following Curricula	Civil Engineering: Specia International Managemer Logistics, Infrastructure Compulsory Logistics, Infrastructure Compulsory Renewable Energies: Sp	and Mobility: Specialisation and Mobility: Specialisation wind Energy Sy	y: Elective Compulsory sation II. Logistics: Elective Compulsory on Production and Logistics: Elective n Infrastructure and Mobility: Elective

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0063: Maritim	e Transport				
Тур	Lecture				
Hrs/wk					
СР					
Workload in Hours	dependent 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: Maritim	ne 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.

echanical Design Methodo	logy			
	Typ Lecture Recitation Section (small)	Hrs/wk 3 1	CP 4 2	
Prof. Josef Schlattmann				
After taking part successfully, student	s have reached the following lea	Irning resul	ts	
Colonoo hoood working on are ducted	nion considering toracted and	option of		
Science-based working on product design considering targeted application of specific product design techniques				
Creative handling of processes used for scientific preparation and formulation of comple product design problems / Application of various product design techniques followin theoretical aspects.				
	Time in Lecture 56			
	incering. Openialization II. Dro			
Productional Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Productio Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsor				
	dology (L1523) dology (L1524) Prof. Josef Schlattmann None After taking part successfully, student Science-based working on product de design techniques Creative handling of processes use product design problems / Applica theoretical aspects. Independent Study Time 124, Study T 6 None Oral exam 30 min International Management and Eng Production: Elective Compulsory Mechatronics: Specialisation System Biomedical Engineering: Specialisati Compulsory Biomedical Engineering: Specialisati Biomedical Engineering: Specialisati Compulsory Biomedical Engineering: Specialisati	dology (L1523) Lecture dology (L1524) Recitation Section (small) Prof. Josef Schlattmann None After taking part successfully, students have reached the following lead Science-based working on product design considering targeted applid design techniques Science-based working on product design considering targeted applid design techniques Creative handling of processes used for scientific preparation and product design problems / Application of various product design theoretical aspects. Independent Study Time 124, Study Time in Lecture 56 6 None Oral exam 30 min International Management and Engineering: Specialisation II. Prof. Production: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regene Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Biomedical Engineering: Specialisation Management and Business Compulsory Biomedical Engineering: Specialisation Management and Business Compulsory Biomedical Engineering: Specialisation Management and Business Compulsory Theoretical Mechanical Engineering: Specialisation Product Devel	Typ Hrs/wk dology (L1523) Lecture 3 dology (L1524) Recitation Section (small) 1 Prof. Josef Schlattmann None After taking part successfully, students have reached the following learning results in the section of section (small) in the section of section (section of section (section of section (section of section of section (section of section of section of section (section of section of section (section of section of section of section of section (section (section (section (section of section (section of section (section (section (section (section of section (section (s	

Course L1523: Mecha	nical Design Methodology
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Josef Schlattmann
Language	DE
Cycle	SoSe
Content	 Systematic reflection and analysis of the mechanical design process Process structuring in sections (task, functions, acting principles, design-elements and total construction) as well as levels (working-, controlling-, and deciding-levels) Creativity (basics, methods, practical application in mechatronics) Diverse methods applied as tools (function structure, GALFMOS, AEIOU method, GAMPFT, simulation tools, TRIZ) Evaluation and selection (technical-economical evaluation, preference matrix) Value analysis, cost-benefit analysis Low-noise design of technical products Project monitoring and leading (leading projects / employees, organisation in product development, creating ideas / responsibility and communication) Aesthetic product design (industrial design, colouring, specific examples / exercises)
Literature	 Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 VDI-Richtlinien: 2206; 2221ff



Course L1524: Mecha	nical Design Methodology
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Josef Schlattmann
Language	DE
Cycle	SoSe
Content	 Systematic reflection and analysis of the mechanical design process Process structuring in sections (task, functions, acting principles, design-elements and total construction) as well as levels (working-, controlling-, and deciding-levels) Creativity (basics, methods, practical application in mechatronics) Diverse methods applied as tools (function structure, GALFMOS, AEIOU method, GAMPFT, simulation tools, TRIZ) Evaluation and selection (technical-economical evaluation, preference matrix) Value analysis, cost-benefit analysis Low-noise design of technical products Project monitoring and leading (leading projects / employees, organisation in product development, creating ideas / responsibility and communication) Aesthetic product design (industrial design, colouring, specific examples / exercises)
Literature	 Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 VDI-Richtlinien: 2206; 2221ff

Module M0805: ⁻	Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho			
Acoustics)	, , , , , , , , , , , , , , , , , , ,			
Courses				
Title Technical Acoustics I (Ac (L0516)	TypHrs/wkCPoustic Waves, Noise Protection, Psycho Acoustics) Lecture23			
	oustic Waves, Noise Protection, Psycho Acoustics) Recitation Section (large) 2 3			
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional				
Competence Knowledge	The students possess an in-depth knowledge in acoustics regarding acoustic waves, noise			
Skills	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding methodologies and measurement procedures treated within the module.			
Personal Competence				
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.			
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible conflicting issues and limitations can be identified and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	19() min			
Assignment for the Following Curricula				

Course L0516: Technie	cal Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)			
Тур	Lecture			
Hrs/wk				
СР				
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: Technie	ourse L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)		
Тур	Typ 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		-	ур	Hrs/wk	СР
Modeling Across The Sca Modeling Across The Sca		-	ecture ecitation Section (sma	2 II) 2	3 3
-	Prof. Christian Cyron		(,	_
Admission Requirements	None				
Recommended	Basics of linear and nonline Mechanics II and Continuum M strain, free-body principle, linea	Aechanics (force:	s and moments, str	ess, linear	
Educational Objectives	After taking part successfully, st	udents have reac	ched the following le	arning resul	lts
Professional Competence					
Knowledge	The students can describe different deformation mechanisms on different scales and can name the appropriate kind of modeling concept suited for its description.				
Skills	The students are able to predict first estimates of the effective material behavior based on the material's microstructure. They are able to correlate and describe the damage behavior o materials based on their micromechanical behavior. In particular, they are able to apply thei knowledge to different problems of material science and evaluate and implement materia models into a finite element code.				
Personal Competence					
Social Competence	The students are able to deve ideas further.	lop solutions, to	present them to s	pecialists a	nd to develo
Autonomy	The students are able to a independently and on their ow modeling and acquire the know	vn identify and s	solve problems in th		•
Workload in Hours	Independent Study Time 124, S	tudy Time in Lec	ture 56		
Credit points	6				
Course achievement	None				
Examination					
Examination duration and scale	45 min				
Assignment for the Following Curricula	LINGOTOUCAL MICCOADICAL ENOIDOGODO, TOCODICAL COMOLOMODIANY COURSO, EleCIMO COMOLISON				



Course L1537: Modelin	ng Across The Scales
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	SoSe
Content	 modeling of deformation mechanisms in materials at different scales (e.g., molecular dynamics, crystal plasticity, phenomenological models,) relationship between microstructure and macroscopic mechanical material behavior Eshelby problem effective material properties, concept of RVE homogenisation methods, coupling of scales (micro-meso-macro) micromechanical concepts for the description of damage and failure behavior
Literature	 D. Gross, T. Seelig, Bruchmechanik: Mit einer Einführung in die Mikromechanik, Springer T. Zohdi, P. Wriggers: An Introduction to Computational Micromechanics D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch G. Gottstein., Physical Foundations of Materials Science, Springer



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



Courses							
Title			Тур	Hrs/wk	СР		
Boundary Element Metho Boundary Element Metho			Lecture Recitation Section (large)	2 2	3 3		
Module Responsible	Prof. Otto von Estorff						
Admission Requirements	None						
Recommended Previous Knowledge	Dynamics)	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)					
Educational Objectives	After taking part successfu	lly, students have re	ached the following lea	rning resul	ts		
Professional							
Competence	The students possess a	n in-depth knowled	lae regarding the dori	vation of t	he hounda		
	element method and are	•					
Knowledge	the method.						
Kilowieuge							
Skills	elements, assembling the equations.	corresponding syst	em matrices, and solvin	g the result	ling system		
Personal Competence							
Social Competence	Students can work in smal	l groups on specific	problems to arrive at joi	int solutions	3.		
Autonomy	The students are able to develop own boundary e critically scrutinized.			•			
Workload in Hours	Independent Study Time 1	24, Study Time in Lo	ecture 56				
Credit points	6						
Course achievement	Compulsory BonusNo20 %	Form Midterm	Descriptio	n			
Examination	Written exam						
Examination duration and scale	90 min						



Assignment for the	Mechanical	Engineering	and	Management:	Specialisation	Product	Development	and
Following Curricula	Production: I	elective Comp	ulsory	/				
i oliotinig ourrioulu	Mechatronic	s: Specialisati	on Sy	stem Design: Ele	ective Compulso	ry		
					: Core qualificati			
	Technomath	ematics: Spec	ialisa	tion III. Engineer	ing Science: Ele	ctive Com	npulsory	
	Theoretical N	Mechanical En	ginee	ering: Core quali	fication: Elective	Compuls	ory	
	Theoretical N	Nechanical En	ginee	ering: Technical	Complementary	Course: E	lective Compu	lsory

ourse L0523: Bounda	ary Element 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
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: Bounda	Course 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		



Courses							
Title Humanoid Robotics (L066	3)				Typ Seminar	Hrs/wk 2	CP 2
Module Responsible	Patrick	Göttsch					
Admission Requirements	None						
Recommended Previous Knowledge			n to control sy ory and desig				
Educational Objectives	After ta	ıking part sı	iccessfully, st	tudents have	e reached the follov	ving learning resu	lts
Professional Competence							
Knowledge			an explain hu earn to apply		ots. I concepts for differ	ent tasks in huma	noid robotics.
Skills	 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 						
Personal Competence							
Social Competence	•	them	able to provi		g solutions in inter ate feedback and		
Autonomy	 Students evaluate advantages and drawbacks of different forms of presentation fo specific tasks and select the best solution Students familiarize themselves with a scientific field, are able of introduce it and follow presentations of other students, such that a scientific discussion develops 						
Workload in Hours	Indepe	endent Stud	y Time 32, St	udy Time in	Lecture 28		
Credit points	2						
Course achievement	None						
Examination		ntation					
Examination duration and scale	30 min						
Assignment for the Following Curricula	Mecha Biomeo Compu Biomeo	tronics: Spe dical Engin ulsory dical Engin dical Engin	ecialisation S eering: Speci eering: Speci	ystem Desig alisation Art alisation Imp	stems and Robotics In: Elective Compul ificial Organs and I plants and Endopro Medical Technolog	sory Regenerative Mec ostheses: Elective	licine: Elective

Compulsory	I
Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory	•
Theoretical Mechanical Engineering: Core qualification: Elective Compulsory	

Course L0663: Human	oid 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 Linear and Nonlinear Syst	em Identification (L0660)	Typ Lecture	Hrs/wk 2	СР 3				
Module Responsible								
Admission Requirements	None							
Recommended Previous Knowledge	State space methodsDiscrete-time systemsLinear algebra, singular value	 Discrete-time systems Linear algebra, singular value decomposition 						
Educational Objectives	After taking part successfully, students	have reached the follow	ving learning resu	lts				
Professional Competence								
Knowledge	 Students can explain the general framework of the prediction error method and it application to a variety of linear and nonlinear model structures They can explain how multilayer perceptron networks are used to model nonlinear dynamics They can explain how an approximate predictive control scheme can be based or neural network models They can explain the idea of subspace identification and its relation to Kalmar realisation theory 							
Skills	 Students are capable of applying the predicition error method to the experiment identification of linear and nonlinear models for dynamic systems They are capable of implementing a nonlinear predictive control scheme based on neural network model They are capable of applying subspace algorithms to the experimental identification linear models for dynamic systems They can do the above using standard software tools (including the Matlab Syste Identification Toolbox) 							
Personal Competence								
Social Competence	Students can work in mixed groups on	specific problems to an	rive at joint solution	ıs.				
Autonomy	Students are able to find required information in sources provided (lecture notes, literature software documentation) and use it to solve given problems.							
Workload in Hours	Independent Study Time 62, Study Tim	e in Lecture 28						
Credit points	3							
Course achievement	None							
Examination	Oral exam							
Examination duration and scale	30 min							
Course achievement Examination Examination duration	None Oral exam 30 min			-				

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

Course L0660: Linear	and Nonlinear System Identification				
Тур	Lecture				
Hrs/wk	2				
СР					
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 Computational Fluid Dyna Computational Fluid Dyna Statistical Thermodynamic	mics in l	Process Engi	neering (L1	052)	Typ Recitation Sect Lecture Lecture	ion (small)	Hrs/wk 1 2 2	CP 1 2 3
Module Responsible	Prof. N	lichael Schl	üter					
Admission Requirements								
Recommended Previous Knowledge	•		vledge in F	luid Mechanics hemical thermo	dynamics			
Educational Objectives	After ta	iking part su	uccessfully	, students have	reached the follo	owing lea	rning resul	lts
Professional Competence								
Knowledge	 After successful completion of the module the students are able to explain the the basic principles of statistical thermodynamics (ensembles, simp systems) describe the main approaches in classical Molecular Modeling (Monte Carl Molecular Dynamics) in various ensembles discuss examples of computer programs in detail, 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 problems by Monte Carlo or molecu 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. 							
Personal Competence	The et	udents are a	able to					
Social Competence	•	develop jo	int solution		ns and present th their own contri			her students
Autonomy	•	basis,	neir learnir		to define the f	-	steps of le	arning on th

Credit points	6
Course achievement	None
Examination	
Examination duration and scale	30 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Process Engineering: Specialisation Energy Systems: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L1375: Compu	itational 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: Compu	tational Fluid Dynamics in Process Engineering			
Тур	Lecture			
Hrs/wk	2			
CP	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	rof. 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 			



Course L0099: Statisti	cal Thermodynamics and Molecular Modelling
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Sven Jakobtorweihen
Language	EN
Cycle	SoSe
Content	 Some lectures will be carried out as computer exercises Introduction to Statistical Mechanics The ensemble concept The classical limit Intermolecular potentials, force fields Monte Carlo simulations (acceptance rules) (Übungen im Rechnerpool) (exercises in computer pool) Molecular Dynamics Simulations (integration of equations of motion, calculating transport properties) (exercises in computer pool) Molecular simulation of Phase equilibria (Gibbs Ensemble) Methods for the calculation of free energies
Literature	Daan Frenkel, Berend Smit: Understanding Molecular Simulation, Academic Press M. P. Allen, D. J. Tildesley: Computer Simulations of Liquids, Oxford Univ. Press A.R. Leach: Molecular Modelling - Principles and Applications, Prentice Hall, N.Y. D. A. McQuarrie: Statistical Mechanics, University Science Books T. L. Hill: Statistical Mechanics , Dover Publications

Module M0752: N	Ionlinear Dynamics						
Courses							
Title Nonlinear Dynamics (L07	02)	Typ Integrated Lecture	Hrs/wk 4	CP 6			
Module Responsible	Prof. Norbert Hoffmann						
Admission Requirements	None						
Recommended Previous Knowledge	Linear Algebra						
Educational Objectives	After taking part successfully, students have	reached the following lo	earning resu	Its			
Professional Competence							
Knowledge	develop and research new terms and concepts.						
Skills	Students are able to apply existing methods and procesures of Nonlinear Dynamics and to develop novel methods and procedures.						
Personal Competence							
-	l Students can reach working results also in g	roups					
Autonomy	Students are able to approach given research tasks individually and to identify and follow ur						
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56					
Credit points	6						
Course achievement	None						
Examination	Written exam						
Examination duration and scale	2 Hours						
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsor Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory						

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.		

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Courses						
Title Optimal and Robust Conti	ol (1.06)	58)	Typ Lecture		Hrs/wk 2	СР 3
Optimal and Robust Contr Optimal and Robust Contr			Recitation Section			3
Module Responsible						
Admission Requirements	None					
Recommended Previous Knowledge	•	Classical control (frequen State space methods Linear algebra, singular v				
Educational Objectives	After ta	aking part successfully, stu	dents have reached the followi	ng lear	ning resul	ts
Professional Competence						
Knowledge	• • •	LQ problems. They can explain the c estimation. They can explain how the performance constraints. They can explain how ar an H2 design problem. They can explain how m to robust controller design They can explain how - guarantee stability and per	based on the small gain theo erformance for an uncertain pla nalysis and synthesis conditio	feedb used to formul sented i orem - unt.	ack and o represer ated as s n a way th a robust	optimal st nt stability a pecial case nat lends its controller o
Skills	•	models. They are capable of repr generalized plant, and of They are capable of tran loops into constraints on sensitivity design. They are capable of con and of designing a mixed They are capable of forr inequalities (LMI), and of	designing and tuning LQG co resenting a H2 or H-infinity de using standard software tools f slating time and frequency do closed-loop sensitivity function structing an LFT uncertainty n -objective robust controller. nulating analysis and synthes using standard LMI-solvers for ne above using standard softwa	esign p for solvi main s is, and nodel fo sis con- solving	roblem in ing it. pecification of carrying or an unc ditions as them.	the form of ons for con g out a mixe ertain syste linear ma
Personal Competence						
Social Competence			os on specific problems to arriv	-		
Autonomy	softwa	-	ed information in sources provention in sources provention in solve given problems.	vided (I	ecture no	ites, literatu

Workload in Hours	dependent Study Time 124, Study Time in Lecture 56					
Credit points						
Course achievement	ne					
Examination						
Examination duration and scale	min					
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory					



Course L0658: Optima	I and 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: Optima	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			

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Module Manual M.Sc.	"Theoretical Mechanical Engineering"			Hamburg University o
Module M1156: S	systems Engineering			
Courses				
Title		Тур	Hrs/wk	СР
Systems Engineering (L1	547)	Lecture	3	4
Systems Engineering (L1	548)	Recitation Section (large)	1	2
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Previous knowledge in: • Aircraft Cabin Systems			
Educational Objectives	After taking part successfully, students have	e reached the following lea	rning resu	lts
Professional Competence				
Knowledge	Students are able to: • understand systems engineering process complex Systems • describe innovation processes and the ne • explain the aircraft development process a	ed for technology Manage	ement	·

Knowledge • explain the aircraft development process and the process of type certification for aircraft • explain the system development process, including requirements for systems reliability • identify environmental conditions and test procedures for airborne Equipment

 value 	the	methodology	of	requirements-based	engineering	(RBE)	and	model-based	l
requirem	nents	engineering (I	MBI	RE)					
									l

Students are able to:
 plan the process for the development of complex Systems

		•		
Skills	• organize the o	development phases and	d development	Tasks

NIIIS	• assign	required	business	activities	and te	chnical	Tasks	
	0							

• apply systems engineering methods and tools

Competence

	 3	3	 	

- Personal
- Students are able to: Social Competence • understand their responsibilities within a development team and integrate themselves with their role in the overall process

	Students are able to:
Autonomy	 interact and communicate in a development team which has distributed tasks

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 Minutes
	Aircraft Systems Engineering: Core qualification: Compulsory

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

Course L1547: System	ns Engineering		
Тур	Lecture		
Hrs/wk	3		
СР	4		
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	rof. Ralf God		
Language	DE		
Cycle	SoSe		
Content	The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integration of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineering process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known. Key aspects of the course are processes for innovation and technology management, system design, system integration and certification as well as tools and methods for systems engineering: • Innovation processes • IP-protection • Technology management • Systems engineering • Aircraft program • Certification issues • Systems development • Safety objectives and fault tolerance • Environmental and operating conditions • Tools for systems engineering • Requirements-based engineering (RBE) • Model-based requirements engineering (MBRE)		
Literature	 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: System	Course L1548: Systems Engineering		
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Ralf God		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		



Module M1302: A	pplied Humanoid Robotics			
Courses				
Title		Тур	Hrs/wk	СР
Applied Humanoid Robotic	cs (L1794)	Project-/problem-based Learning	6	6
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous Knowledge	 Object oriented programming; Introduction to control systems Control systems theory and de Mechanics 			
Educational Objectives	After taking part successfully, students	s have reached the following lea	arning resu	Its
Professional Competence				
Knowledge	 Students can explain humanoid robots. Students can explain the basic concepts, relationships and methods of forward- and inverse kinematics Students learn to apply basic control concepts for different tasks in humanoid robotics. 			
Skills	 Students can implement models for humanoid robotic systems in Matlab and C++, and use these models for robot motion or other tasks. They are capable of using models in Matlab for simulation and testing these models if necessary with C++ code on the real robot system. They are capable of selecting methods for solving abstract problems, for which no standard methods are available, and apply it successfully. 			
Personal Competence				
Social Competence	 Students can develop joint sol They can provide appropriate on their own results 	-		ndle feedbac
Autonomy	 Students are able to obtain re to put in into the context of the They can independently define 	lecture.		
Workload in Hours	Independent Study Time 96, Study Tir	me in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and scale	5-10 pages			
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory 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			

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)E/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) 		

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Module M1170: P	henomena and Methods in M	laterials Science)		
Courses					
TitleTypHrs/wkExperimental Methods for the Characterization of Materials (L1580)Lecture2Phase equilibria and transformations (L1579)Lecture2			CP 3 3		
Module Responsible	Prof. Patrick Huber				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge in Materials Science, o	e.g. Werkstoffwissensc	haft I/II		
Educational Objectives	After taking part successfully, students h	nave reached the follow	ving learning resul	lts	
Professional Competence					
Knowledge	The students will be able to explain the properties of advanced materials along with their				
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications.				
Personal Competence Social Competence	The students are able to present solutions to specialists and to develop ideas further.				
Autonomy	 The students are able to assess their own strengths and weaknesses. gather new necessary expertise by their own. 				
Workload in Hours	Independent Study Time 124, Study Tim	ne in Lecture 56			
Credit points					
Course achievement					
-	Written exam				
Examination duration and scale	90 min				
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Core qualification: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development Materials and Production: Specialisation Production: Elective				

Course L1580: Experin	mental 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	Prof. Patrick Huber
Language	DE
Cycle	SoSe
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	equilibria and transformations
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Jörg Weißmüller
Language	DE
Cycle	SoSe
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	Wird im Rahmen der Lehrveranstaltung bekannt gegeben.



Module M1281: A	Advanced Topics in Vib	ration			
Courses					
Title		Тур	Hrs/wk	СР	
Advanced Topics in Vibra	tion (L1743)	Project-/problem-based Learning	4	6	
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	Vibration Theory				
Educational Objectives	Attor taking nart europeetully et	udents have reached the following le	arning resu	lts	
Professional Competence					
Knowledge	Students are able to reflect existing terms and concepts of Advanced Vibrations and to develop and research new terms and concepts.				
Skills	Students are able to apply existing methods and procesures of Advanced Vibrations and to develop nove methods and procedures.				
Personal Competence					
Social Competence	Students can reach working results	s also in groups.			
Autonomy	Students are able to approach giresearch tasks by themselves.	ven research tasks individually and to	identify and	follow up nov	
Workload in Hours	Independent Study Time 124, S	Study Time in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale					
-	Mechatronics: Specialisation In Mechatronics: Technical Compl Theoretical Mechanical Engine	ystem Design: Elective Compulsory telligent Systems and Robotics: Elect lementary Course: Elective Compulso ering: Technical Complementary Cou eering: Specialisation Product Deve	ory irse: Electiv	e Compulsor	

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



Module M1335: E	BIO II: Artificial Joint Re	placement		
Courses				
Title Artificial Joint Replacemen	nt (L1306)	Typ Lecture	Hrs/wk 2	СР 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic	and surgical techniques is recor	mmended.	
Educational Objectives	After taking part successfully, st	udents have reached the followi	ng learning resul	ts
Professional Competence				
Knowledge	The students can name the diffe	erent kinds of artificial limbs.		
Skills	The students can explain t endoprotheses.	he advantages and disadva	ntages of differ	ent kinds of
Personal Competence				
Social Competence		ss issues related to endoprothe	se with student r	nates and the
Autonomy	The students are able to acquir with respect to its credibility.	e information on their own. They	can also judge tl	ne information
Workload in Hours	Independent Study Time 62, St	udy Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Orientierungsstudium: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			



Tvn	Lecture
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Michael Morlock
Language	DE
Cycle	SoSe
	Inhalt (deutsch)
Content	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenke satzes)
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportlic Aktivität)
	3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannensei Evolution der Implantate)
	4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibia 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, Reibur 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, Ne York 1994
	Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febig Philadelphia, 1989.
	Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.
	Sobotta und Netter für Anatomie der Gelenke

analysis	DESI	gn optimization and pro		JIIC5 III	Structure
Courses					
(L1873)		stic Approaches in Structural Analysis stic Approaches in Structural Analysis	Typ Lecture Recitation Section (large	Hrs/wk 2	СР 3 3
Module Responsible	Prof. B	enedikt Kriegesmann			
Admission Requirements	l				
Recommended Previous Knowledge		Technical mechanics Higher math			
Educational Objectives	Δttor to	king part successfully, students hav	re reached the following le	arning resu	llts
Professional Competence					
Knowledge	•	 Design optimization Gradient based methods Genetic algorithms Optimization with constraint Topology optimization Reliability analysis Stochastic basics Monte Carlo methods Semi-analytic approaches robust design optimization Robustness measures Coupling of design optimization 		S	
Skills		Application of optimization algorit structures Programming with Matlab Implementation of algorithms Debugging	thms and probabilistic m	ethods in	the design
Personal Competence					
Social Competence		Team work Oral explanation of the the work			
Autonomy	•	Application of methods learned in the Familiarizing with source code provide Description of approaches and rest	vided	vork	
Workload in Hours	Indepe	ndent Study Time 124, Study Time i	in Lecture 56		
Credit points	6				
Course achievement	None				
Examination	Written	elaboration			

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Course L1873: Design	Optimization and Probabilistic Approaches in Structural Analysis	
Тур	Lecture	
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	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 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		
Content	Matlab exercises complementing the lecture	
Literature	siehe Vorlesung	

ourses				
itle Compilers for Embedded S	Systems (L1692)	Typ Lecture	Hrs∕wk 3	CP 4
Compilers for Embedded Systems (L1693)		Project-/problem-based Learning	1	2
Module Responsible	Prof. Heiko Falk			
Admission Requirements	None			
Recommended	Module "Embedded Systems"			
	C/C++ Programming skills			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	 to distinguish and explain i and to assess optimizations and The high demands on compilers f mandatory. The students learn in particular in particular in particular in the students learn in particular in the students of optimizations which kinds of optimizations how the translation from source 	d on embedded processors grow Because of the particular applic oplication-specific processors and h demands on compilers which attendance of this course, the str d organization of such compilers, intermediate representations of their underlying problems in all for embedded systems make eff articular, are applicable at the source coor ince code to assembly code is per- s are applicable at the assembly of artormed, and n be exploited effectively. stems often have to optimize fo time, energy dissipation, code s	ws continuou ration areas re deployed have to ger udents are a various abst compiler pha fective code de level, rformed, code level, r multiple ob	usly due to i of embedde . Such high nerate code ble raction level ases. optimization
Skills	After successful completion of the program code into machine code optimization should be applied m assembly code) within a compiler. While attending the labs, the stud including optimizations.	e. They will be enabled to as ost effectively at which abstrac	sess which tion level (e	kind of coo e.g., source of
Personal Competence				
	Chudanta ava alda ta adua amailar	problems alone or in a group	and to proof	ant the regul

Autonomy	knowledge with other classes.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	
Examination duration and scale	30 min
Assignment for the Following Curricula	Mechatronics, Specialisation System Design, Flective Compulsory

Course L1692: Compil	ers for Embedded Systems		
Тур	Lecture		
Hrs/wk	3		
СР	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. 2nd 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 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

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Courses				
Fitle Structure and properties o Design with fibre-polymer-	f fibre-polymer-composites (L1894) composites (L1893)	Typ Lecture Lecture	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. Bodo Fiedler			
Admission Requirements	None			
Recommended Previous Knowledge	Basics: chemistry / physics / materials se	cience		
Educational Objectives	After taking part successfully, students h	ave reached the follow	wing learning resu	lts
Professional Competence				
	Students can use the knowledge of fib play (fiber / matrix) and define the necess			constituents
Knowledge	They can explain the complex relations	nips structure-property	relationship and	
	the interactions of chemical structure o types, including to explain neighboring		-	
Skills	 Students are capable of using standardized calculation methods in a given context to mechanical propertie (modulus, strength) to calculate and evaluate the different materials. approximate sizing using the network theory of the structural elements implement and evaluate. selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance. 			
Personal Competence	Studente con			
Social Competence	 Students can arrive at funded work results in heterogenius groups and document them. provide appropriate feedback and handle feedback on their own performanc constructively. 			
	Students are able to			
	- assess their own strengths and weakn		dofine further worl	(atoma an t
Autonomy	 assess their own state of learning in specific terms and to define further work steps on thi basis. assess possible consequences of their professional activity. 			
	Independent Study Time 124, Study Tim	ne in Lecture 56		
Credit points				
Course achievement Examination				

Examination duration and scale	
Assignment for the Following Curricula	Flective Compulsory

Course L1894: Structure and properties of fibre-polymer-composites		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Bodo Fiedler	
Language	EN	
Cycle	SoSe	
Content	 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	

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

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Module M1306: C	Control Lab C			
Courses				
Title Control Lab IX (L1836) Control Lab VII (L1834) Control Lab VIII (L1835)		Typ Practical Course Practical Course Practical Course	Hrs/wk 1 1 1	CP 1 1 1
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	H2 and H-infinity optimal control	st control		
Educational Objectives	After taking part successfully students ha	ave reached the following	learning resu	lts
Professional Competence				
Knowledge	 Students can explain the difference between validation of a control lop in simulation and experimental validation 		in simulation	
Skills	 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers 			
Personal Competence				
Social Competence	• Students can work in teams to co	nduct experiments and do	cument the re	sults
Autonomy	 Students can independently carry loops 	y out simulation studies to	design and v	alidate control
Workload in Hours	Independent Study Time 48, Study Time	in Lecture 42		
Credit points	3			
Course achievement	None			
Examination	Written elaboration			
Examination duration and scale				
Assignment for the	Electrical Engineering: Specialisation Compulsory Mechatronics: Specialisation Intelligent S		-	-

Following Curricula Mechatronics: Specialisation System Design: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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Course L1836: Contro	ourse L1836: Control Lab IX		
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		

Course 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
	WiSe/SoSe
	One of the offered experiments in control theory.
Literature	Experiment Guides

Course L1835: Control Lab VIII		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
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	
	One of the offered experiments in control theory.	
Literature	Experiment Guides	

Module M1239: E	experimental Micro- and Nano	mechanics		
Courses				
Title Experimental Micro- and N Experimental Micro- and N		Typ Lecture Recitation Sectio	Hrs/wk 2 n (small) 1	CP 4 2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Salanaa			
Educational Objectives	After taking part successfully students ha	ave reached the follow	wing learning resu	lts
Professional Competence				
Knowledge	Students are able to describe the principles of mechanical behavior (e.g., stress, strain, modulus, strength, hardening, failure, fracture). 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			
Skills	properties. Students are capable of using standardized calculation methods to calculate and evaluate mechanical properties (modulus, strength) of different materials under varying loading states (e.g., uniaxial stress or plane strain).			
Personal Competence				
Social Competence	Students can provide appropriate feedback and handle feedback on their own performance constructively.			
	Students are able to - assess their own strengths and weakne	esses		
Autonomy	- assess their own state of learning in s basis guided by teachers.	pecific terms and to o	define further work	steps on this
	 to be able to work independently base for help or clarifications when needed 	d on lectures and not	tes to solve proble	ms, and to ask
Workload in Hours	Independent Study Time 138, Study Time	e in Lecture 42		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Materials Science: Specialisation Nano a Theoretical Mechanical Engineering: Sp Theoretical Mechanical Engineering: Te	ecialisation Materials	Science: Elective	Compulsory

ourse L1673: Experin	mental Micro- and Nanomechanics
Тур	Lecture
Hrs/wk	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 scale A focus will be made on metallic materials, though issues related to ceramics and polymen materials will also be discussed. Modern methods will be explored, along with the scienti 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 Size effects in yield strength and hardening Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Principles of contact in yield strength and hardening Microbeam-bending Principles of contact in yield strength and hardening Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbeam-bending Microbea
Literature	Vorlesungsskript Aktuelle Publikationen

Course L1674: Experi	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	

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Module M1226: M	lechanical Properties			
Courses				
Title Mechanical Behaviour of P Dislocation Theory of Plas		Typ Lecture Lecture	Hrs/wk 2 2	CP 3 3
Module Responsible	Dr. Erica Lilleodden			
Admission Requirements				
Recommended Previous Knowledge	Basics in Materials Science I/II			
Educational Objectives	After taking part successfully, students	have reached the follow	ring learning resu	lts
Professional Competence				
	Students can explain basic principles and thermodynamics (energy minimized)			ams, tractions
Skills	Students are capable of using standardized calculation methods: tensor calculations derivatives, integrals, tensor transformations			
Personal Competence				
Social Competence	Students can provide appropriate feedback and handle feedback on their own performance constructively.			
	Students are able to - assess their own strengths and weak		ofine further work	, etcho on th
Autonomy	 assess their own state of learning in specific terms and to define further work steps on this basis guided by teachers. work independently based on lectures and notes to solve problems, and to ask for help or clarifications when needed 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula				



Course L1661: Mecha	nical Behaviour 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
	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
Content	Heterogeneous materials III Toughening mechanisms. Process zone
	Testing methods to determine the fracture toughness of brittle materials
	R-curve, stable/unstable crack growth, fractography
	Thermal shock
	Subcritical crack growth) v-K-curve, life time prediction
	Kriechen
	Mechanical properties of biological materials
	Examples of use for a mechanically reliable design of ceramic components
	D R H Jones, Michael F. Ashby, Engineering Materials 1, An Introduction to Properties Applications and Design, Elesevier
	D.J. Green, An introduction to the mechanical properties of ceramics", Cambridge University Press, 1998
Literature	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: Disloca	ation Theory of Plasticity
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Erica Lilleodden
Language	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



Module M1238: G	Quantum Mechanics of Soli	ids		
Courses				
Title		Тур	Hrs/wk	СР
Quantum Mechanics of Se		Lecture	2	4
Quantum Mechanics of Se	olids (L1676)	Recitation Section	(small) 1	2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Knowledge of advanced mathemati complex functions, e.g., Mathematic: Knowledge of mechanics and physic	s I-IV		
Educational Objectives	After taking part successfully, studer	nts have reached the follow	ing learning resu	llts
Professional				
Competence	The master students will be able to e	avolain		
	the basics of quantum mechanics.			
	the importance of quantum physics for the description of materials properties.			
Knowledge	correlations between on quantum mechanics based phenomena between individual atom and macroscopic properties of materials.			
	The master students will then be able to connect essential materials properties in engineerin with materials properties on the atomistic scale in order to understand these connections.			
	After attending this lecture the stude	nts can		
Skills	-			
Personal Competence				
Social Competence	The students are able to discuss experts from fields such as physics a		echanics-based	subjects w
Autonomy	The students are able to independe They can also acquire the knowled quantum mechanical background fro	ge they need to deal with	•	•
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 Nano and Hybrid Materials: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			



ourse L1675: Quantu	m Mechanics 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	SoSe
Content	 Introduction Relevance of Quantum Mechanics Classification of Solids Foundations of Quantum Mechanics Foundations of Quantum Mechanics Meminder : Elements of Classical Mechanics Motivation for Quantum Mechanics Particle-Wave Duality Particle-Wave Duality Formalism Elementary QM Problems Onedimensional Problems of a Particle in a Potential Two-Level System Harmonic Oscillator Electrons in a Magnetic Field Flydrogen Atom Quantum Effects in Condensed Matter Preliminary Electronic Levels Magnetism Superconductivity Superconductivity Superconductivity
	Physik für Ingenieure, Hering/Martin/Stohrer, Springer Atom- und Quantenphysik, Haken/Wolf, Springer
Literature	Grundkurs Theoretische Physik 5 1, Nolting, Springer
	Electronic Structure of Materials, Sutton, Oxford Materials Science and Engineering: An Introduction, Callister/Rethwisch, Edition 9, Wiley

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



Courses					
Title Methods in Theoretical Ma Methods in Theoretical Ma			Typ Lecture Recitation Sectior	Hrs/wk 2 n (small) 1	CP 4 2
Module Responsible	Prof. Stefan Müller				
Admission Requirements	None				
Recommended Previous Knowledge	Knowledge of advanced complex functions, e.g., M Knowledge of physics, pa	lathematics I-IV			equations ar
Educational Objectives	After taking part successfi	ully, students hav	e reached the follow	ring learning resu	llts
Professional Competence					
	The master students will b	be able to			
	explain how different modeling methods work.				
	assess the field of application of individual methodological approaches.				
Knowledge	evaluate the strengths and weaknesses of different methods.				
	The students are thereby able to assess which method is best suited to solve a scientific problem and what accuracy can be expected from the simulation results.				
	After completing the mod	ule, the students a	are able to		
Skills	select the most suitable modeling method as a function of various parameters such as length scale, time scale, temperature, material type, etc				
Personal Competence					
Social Competence	The students are able to from various fields includ exhibitions. Further, this p	ding physics and	materials science,	for example at o	conferences
	The students are able to .				
	assess their own strengths and weaknesses.				
Autonomy	acquire the knowledge they need on their own.				
Workload in Hours	Independent Study Time	138, Study Time i	in Lecture 42		
Credit points					
Course achievement					
Examination					
Examination duration and scale					

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

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Course L1677: Method	ourse L1677: Methods in Theoretical Materials Science		
Тур	Lecture		
Hrs/wk			
CP	4		
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28		
Lecturer	Prof. Stefan Müller		
Language	DE/EN		
Cycle	SoSe		
Content	 Introduction Introduction Classification of Modelling Approaches and the Solid State Quantum Mechanical Approaches Electronic states : Atoms, Molecules, Solids Density Functional Theory Spin-Dynamics Thermodynamic Approaches Thermodynamic Potentials Alloys Cluster Expansion 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: Method	Course L1678: Methods in Theoretical Materials Science	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
Workload in Hours	ndependent Study Time 46, Study Time in Lecture 14	
Lecturer	rof. Stefan Müller	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1175: Speed Water Ver	Special Topics of Ship nicles	Propulsionand	Hydrodynamic	s of High
Courses				
Title Hydrodynamics of High S Special Topics of Ship Pro	peed Water Vehicles (L1593) opulsion (L1589)	Typ Lecture Lecture	Hrs/wk 3 3	CP 3 3
Module Responsible	Prof. Moustafa Abdel-Maksoud			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge on ship resistan	ce, ship propulsion and p	ropeller theory	
Educational Objectives	After taking part successfully, stud	lents have reached the fol	lowing learning resu	lts
Professional Competence				
Knowledge	 Understand present research questions in the field of ship propulsion Explain the present state of the art for the topics considered Apply given methodology to approach given problems 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 systems under different operation conditions by using simplified methods evaluate critically the investigation results of experimental or numerical investigations 			
Personal Competence	Students are able to			
Social Competence				
Autonomy	Students are able to assess their	knowledge by means of e	xercises and case stu	udies
Workload in Hours	Independent Study Time 96, Stud	y Time in Lecture 84		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Naval Architecture and Ocean En Theoretical Mechanical Engineer Theoretical Mechanical Engin Compulsory		ntary Course: Electiv	e Compulsory

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Course L1593: Hydrod	lynamics of High Speed Water Vehicles
Тур	Lecture
Hrs/wk	3
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	 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: Specia	Topics of Ship Propulsion
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	 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

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Courses				_		
Title Automation Technology ar	nd Systems (I	_2329)		Typ Lecture	Hrs∕wk 4	CP 4
Automation Technology ar	nd Systems (I	_2331)		Project-/problem-based Learning	1	1
Automation Technology ar	nd Systems (I	_2330)		Recitation Section (small)	1	1
Module Responsible	Prof. Thorst	en Schüppstuhl				
Admission Requirements	None					
Recommended Previous Knowledge	without maj	or course assessn	nent			
Educational Objectives	After taking	part successfully,	students have re	ached the following lea	Irning resu	lts
Professional Competence						
Knowledge	 Students know the characteristic components of an automation systems and have goo understanding of their interaction know methods for a systematical analysis of automation tasks and are able to us them have special competences in industrial robot based automation systems 					
Skills	 deve desi inve creation 	lyze complex Auto elop application ba gn subsystems an stigate and evalua	ased concepts ar ad integrate into c ate safety of mac ns for robots and	one system ninery programmable logic co	ntrollers	
Personal Competence						
Social Competence	- develop	ons for automation	-	sks in groups nent with qualified per	sonnel at t	echnical lev
Autonomy	Students ar ana gen deve desi	e able to lyze automation ta erate programs for elop solutions for p gn safety concept	robots and prog practice oriented s for automation	rammable logic device tasks of automation ind	ependently	-
Workload in Hours	Independer	nt Study Time 96, S	Study Time in Leo	cture 84		
Credit points	6					
Course achievement	None					
		m				

and scale	
	Product Development, Materials and Production: Specialisation Product Development:
	Elective Compulsory
	Product Development, Materials and Production: Specialisation Production: Compulsory
	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory
	Product Development, Materials and Production: Specialisation Product Development:
Assignment for the	Elective Compulsory
Following Curricula	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Product Development and Production:
	Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Product Development and Production:
	Elective Compulsory

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

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

Course L2330: Automa	ation Technology and Systems
Тур	Recitation Section (small)
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

Courses					
Title			Тур	Hrs/wk	СР
Intelligent Systems in Medicine (L0331)			Lecture	2	3
Intelligent Systems in Medicine (L0334)			Project Seminar	2	2
ntelligent Systems in Med			Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer				
Admission Requirements	None				
Recommended Previous Knowledge					
Educational Objectives	Atter taking nart successfu	illy, students have re	ached the following lea	rning resu	lts
Professional Competence					
Knowledge	The students are able to analyze and solve clinical treatment planning and decision suppor problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.				
Skills	The students can give regression, and prediction evaluate the implemented	n. They can assess			
Personal Competence					
Social Competence	The students discuss the incoorporate feedback into		groups, provide help	oful feedb	ack and ca
Autonomy	The students can reflect present the results in an a		d document the results	of their w	ork. They ca
Workload in Hours	Independent Study Time 1	10, Study Time in Le	ecture 70		
Credit points	6				
Course achievement	Compulsory BonusYes10 %Yes10 %	Form Written elaboration Presentation	Descriptio	'n	
Examination	Written exam				
Examination duration and scale	YU MINITES				
	Computer Science: Specia Electrical Engineering: Sp Computational Science a Elective Compulsory Mechatronics: Specialisat Biomedical Engineering: S	ecialisation Medical nd Engineering: Spe ion Intelligent System	Technology: Elective C ecialisation Systems En ns and Robotics: Electiv	ompulsory gineering re Compul	and Robotics
Assignment for the					

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

Course L0331: Intellige	ent Systems 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: Intellige	Course 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: Intellige	Course L0333: Intelligent Systems in Medicine	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	



Courses				
Title		Тур	Hrs/wk	СР
Numerical Methods in Shi	o Design (L1271)	Lecture	2	4
Numerical Methods in Shi	o 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 following learning results			
Professional				
Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Stud	y Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	45 min			
-	Naval Architecture and Ocean Eng Theoretical Mechanical Engineerin	÷ .		

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	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 - Mass distributions and longitudinal strength - Hullform Design by CFD- techniques - Propulsor and Rudder Design by CFD Techniques
Literature	Skript zur Vorlesung.

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	

TUHH

Courses				
Γitle Γhermal Engineering (L00		Typ Lecture	Hrs/wk 3	CP 5
Thermal Engineering (LOC		Recitation Section (large)	-	1
	Prof. Gerhard Schmitz			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamic	s, Heat Transfer		
Educational Objectives	After taking part successfully, students have rea	ached the following lea	rning resul	ts
Professional Competence				
Knowledge	Students know the different energy conversion and annual efficiency. They have increased kn in regard to buildings and mobile applications code and other technical relevant rules. They domestic and industrial area and how to contro a furnace and to calculate the transient terr knowledge of emission formations in the flame gases into the atmosphere. They are able oriented languages.	nowledge in heat and r s. They are familiar with r know to differ differen of such heating systems operatures in a furnacion s of small burners and	mass trans n German e t heating s s. They are e. They ha d how to co	fer, especia energy savi ystems in t able to moo ave the bas nduct the fl
Skills	Students are able to calculate the heating demand for different heating systems and to choos the suitable components. They are able to calculate a pipeline network and have the ability perform simple planning tasks, regarding solar energy. They can write Modelica program and can transfer research knowledge into practice. They are able to perform scientific work the field of thermal engineering.			
Personal Competence				
Social Competence	The students are able to discuss in small group	os and develop an appr	oach.	
Autonomy	Students are able to define independently knowledge as well as to find ways to use the kn		nowledge	from existi
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 scale	60 min			
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A Compulsory Energy and Environmental Engineering: S Compulsory Energy Systems: Specialisation Energy System Energy Systems: Specialisation Marine Engine International Management and Engineering:	Specialisation Energy ns: Compulsory pering: Elective Compul	Engineer	ing: Electi
-	[/50]			

Engineering: Elective Compulsory
Product Development, Materials and Production: Core qualification: Elective Compulsory
Renewable Energies: Core qualification: Compulsory
Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
 Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0023: Therma	al Engineering		
Тур	Lecture		
Hrs/wk	3		
СР	5		
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42		
Lecturer	Prof. Gerhard Schmitz		
Language	DE		
Cycle	WiSe		
Content	 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 Engineering		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Gerhard Schmitz	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	



Module M0658: Ir	nnovative CFD A	pproaches			
Courses					
(L0239)	FD Methods in Research and Development		Typ Lecture Recitation Section	Hrs/wk 2	СР 3 3
(L1685)	1		Recitation Section	(Smail) 2	3
Module Responsible	_				
Admission Requirements	Nono				
	Attendance of a comp	utational fluid dynam	ics course (CFD1/CF	D2)	
Recommended Previous Knowledge	Competent knowledge of numerical analysis in addition to general and computationa				computational
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	Student can explain the theoretical background of different CFD strategies (e.g. Lattice- Boltzmann, Smoothed Particle-Hydrodynamics, Finite-Volume methods) and describe the fundamentals of simulation-based optimisation.				
Skills	Student is able to identify an appropriate CFD-based solution strategy on a jusitfied basis.				
Personal					
Competence					
Social Competence	Student should practice her/his team-working abilities, learn to lead team sessions and present solutions to experts.			sessions and	
	Student should be ab	· · ·		ised project inde	pendently,
	Independent Study Ti	me 124, Study Time i	n Lecture 56		
Credit points	6				
Course achievement	Compulsory BonusFormDescriptionYes20 %Written elaboration				
Examination	Oral exam				
Examination duration and scale	30 min				
-	Energy Systems: Core Naval Architecture an Ship and Offshore Teo Theoretical Mechanic Theoretical Mechanic Process Engineering:	d Ocean Engineering chnology: Core qualif al Engineering: Tech al Engineering: Spec	: Core qualification: I ication: Elective Com nical Complementary ialisation Energy Sys	pulsory / Course: Electiv stems: Elective C	e Compulsory ompulsory

Course L0239: Applica	ation 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

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

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Modulo M0508: E	luid Mechanics and	d Ocean Ener	av		
			уу		
Courses					
Title			Тур	Hrs/wk	СР
Energy from the Ocean (L Fluid Mechanics II (L0001			Lecture Lecture	2 2	2 4
•	, Prof. Michael Schlüter		Lecture	L	7
Admission Requirements					
Requirements	None				
Recommended Previous Knowledge	Wärme und Steffübertree				
Educational Objectives	After taking part successfu	ully, students have	reached the follow	ving learning resul	ts
Professional					
Competence		, describe differen	t applications of	fluid mechanics f	or the field o
Knowledge	The students are able to describe different applications of fluid mechanics for the field of Renewable Energies. They are able to use the fundamentals of fluid mechanics for calculations of certain engineering problems in the field of ocean energy. The students are able to estimate if a problem can be solved with an analytical solution and what kind of alternative possibilities are available (e.g. self-similarity, empirical solutions, numerical methods).				
Skills	Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are able to formulate momentum and mass balances to optimiz the hydrodynamics of technical processes. They are able to transform a verbal formulate message into an abstract formal procedure.				
Personal Competence					
	The students are able t	to discuss a give	n problem in sm	all groups and to	o develop ar
Social Competence	approach. They are able to solve a problem within a team, to prepare a poster with the result and to present the poster.				
Autonomy	Students are able to define independently tasks for problems related to fluid mechanics. The are able to work out the knowledge that is necessary to solve the problem by themselves of the basis of the existing knowledge from the lecture.				
Workload in Hours	Independent Study Time	124, Study Time in	Lecture 56		
Credit points					
Course achievement	Compulsory BonusFormDescriptionYes10 %Group discussion				
Examination	Written exam				
Examination duration and scale	3h				
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Renewable Energy: Electiv Compulsory Renewable Energies: Core qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				

Course L0002: Energy	from the Ocean		
Тур	Lecture		
Hrs/wk			
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 		

ourse L0001: Fluid M	echanics 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 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. Verla Sauerländer, Aarau, Frankfurt (M), 1971. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfu Sauerländer 1972. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluide 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 d mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelber New York, 2006. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technische Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008. Kuhlmann, H.C.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethode 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 Strömungsvorgäng 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 Californi 1882. 				

Modulo M0623: k	ndustrial Process A	utomation				
	idustrial Process A	utomation				
Courses						
Title Industrial Process Automa	ation (I 0344)		Typ Lecture	Hrs/wk 2	СР 3	
Industrial Process Automa			Recitation Section (small)		3	
	Prof. Alexander Schlaefer					
Admission Requirements	None					
Recommended Previous Knowledge	Invincinles of algorithms and data atvictures					
Educational Objectives	After taking part successful	lly, students have re	ached the following lea	rning resul	lts	
Professional Competence						
Knowledge	The students can evaluate and assess discrete event systems. They can evaluate properties of processes and explain methods for process analysis. The students can compare methods for process modelling and select an appropriate method for actual problems. They can discuss scheduling methods in the context of actual problems and give a detailed explanation of advantages and disadvantages of different programming methods. The students can relate process automation to methods from robotics and sensor systems as well as to recent topics like 'cyberphysical systems' and 'industry 4.0'.					
Skills	The students are able to develop and model processes and evaluate them accordingly. This involves taking into account optimal scheduling, understanding algorithmic complexity, and implementation using PLCs.					
Personal Competence						
Competence	The students work in teams	s to solve problems				
Social Competence						
Autonomy	The students can reflect their knowledge and document the results of their work.					
Workload in Hours	Independent Study Time 1	24, Study Time in L	ecture 56			
Credit points	6					
Course achievement	Compulsory Bonus No 10 %	Form Excercises	Descriptio	n		
Examination	Written exam					
Examination duration and scale	90 minutes					
	Bioprocess Engineering: Compulsory Chemical and Bioproces Elective Compulsory Chemical and Bioprocess Compulsory	s Engineering: S	pecialisation Chemical	Process	Engineerin	

Assignment for the	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory					
Following Curricula	Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective					
	Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory					
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science					
	Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory					
	Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory					

Course L0344: Industr	ial Process 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: Industr	ourse L0345: Industrial Process Automation		
Тур	Recitation Section (small)		
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	See interlocking course		
Literature	See interlocking course		



Module M0716: H	ierarchical Alg	orithms				
Courses						
Title			Тур	Hrs/wk	СР	
Hierarchical Algorithms (L Hierarchical Algorithms (L			Lecture Recitation Section (sm	2 Iall) 2	3 3	
Module Responsible		1e	(,	-	
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 Technomathematicians Programming experience in C 					
Educational Objectives	After taking part succ	cessfully, students ha	ve reached the following	learning resu	lts	
Professional Competence						
Competence	Students are able to					
Knowledge	 name representatives of hierarchical algorithms and list their characteristics, explain construction techniques for hierarchical algorithms, discuss aspects regarding the efficient implementation of hierarchical algorithms. 					
	Students are able to					
Skills	 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	o					
	Students are able to					
Social Competence	 work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms. 					
	Students are capable	е				
Autonomy	 to assess whether the supporting theoretical and practical excercises are better solved individually or in a team, to work on complex problems over an extended period of time, to assess their individual progess and, if necessary, to ask questions and seek help. 					
Workload in Hours	Independent Study 7	Time 124, Study Time	in Lecture 56			
Credit points						
Course achievement						
Examination Examination duration and scale						
	Computational Scier Mathematical Mode	nce and Engineering Iling in Engineering	deling and Simulation: El Specialisation III. Mather Theory, Numerics, App stems (TUHH): Elective C	natics: Electiv plications: Sp	e Compulsor	

Following Curricula Technomathematics: Specialisation I. Mathematics: Elective Compulsory								
	Theoretical	Mechanical	Engineering:	Specialisation	Numerics	and	Computer	Science:
	Elective Cor	npulsory						
	Theoretical	Mechanical E	ngineering: Te	chnical Comple	mentary Co	ourse:	Elective Co	mpulsory

Course L0585: Hierard	chical Algorithms
Тур	Lecture
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	 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: Hierard	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						
Title Digital Image Analysis (L0	126)	Typ Lecture	Hrs/wk 4	CP 6		
	Prof. Rolf-Rainer Grigat					
Admission Requirements	one					
Recommended Previous Knowledge	System theory of one-dimensional s interpolation and decimation, Fourier (Eigenvalue decomposition, SVD), influence of sample size, correlation a basics of Matlab, basics in optics	transform, linear time-ir basic stochastics and	nvariant systems), I statistics (expect	linear algeb ation value		
Educational Objectives	After taking part successfully, students	have reached the follow	ving learning resul	ts		
Professional Competence						
Knowledge	 Describe imaging processes Depict the physics of sensorics Explain linear and non-linear fi Establish interdisciplinary con context Interpret effects of the most immathematical methods and physical methods and physic	Itering of signals nections in the subject portant classes of imag	-			
Skills	 Students are able to Use highly sophisticated method Identify problems and develop Students can solve simple arithmetic image processing and image analysis Students are able to assess different making areas. Students can undertake a prototypical 	and implement creative al problems relating to systems. nt solution approaches	solutions. the specification a in multidimensic	-		
Personal Competence	k.A.					
Social Competence						
Autonomy	Students can solve image analysis tas	ks independently using	the relevant literat	ure.		
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture 56				
Credit points						

Examination	Written exam
Examination duration and scale	60 Minutes, Content of Lecture and materials in StudIP
Assignment for the Following Curricula	LEOCUS SOTWARE and Signal Processing, Flective 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, color 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

Courses				
Title	Тур	Hrs/wk	СР	
Robotics: Modelling and C	ontrol (L0168) Lecture	3	3	
Robotics: Modelling and Control (L1305) Recitation Section (small) 2				
Module Responsible				
Admission Requirements	None			
	Fundamentals of electrical engineering			
Recommended	Broad knowledge of mechanics			
Previous Knowledge	Fundamentals of control theory			
Educational Objectives	After taking part successfully, students have reached the following	g learning resul	ts	
Professional Competence				
$\kappa n n w a n n \mu$	Students are able to describe fundamental properties of robots multiple problems in robotics.	and solution a	pproaches	
	Students are able to derive and solve equations of motion for various manipulators.			
Skills	Students can generate trajectories in various coordinate systems.			
	Students can design linear and partially nonlinear controllers for robotic manipulators.			
Personal				
Competence	Students are able to work goal-oriented in small mixed groups.			
	Students are able to recognize and improve knowledge deficits in	ndependently.		
Autonomy	With instructor assistance, students are able to evaluate their owr a further course of study.		vel and defi	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
	Written exam			
Examination				
Examination Examination duration and scale		tivo Compulso	,	

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

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

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

TUHH Hamburg University of Technology

Courses				
Title Efficient Algorithms (L012) Efficient Algorithms (L120)		Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. Sieafried Rump			
Admission Requirements				
Recommended	Programming in Matlab and/or C			
Previous Knowledge	Basic knowledge in discrete math	ematics		
Educational Objectives	After taking part successfully, students have	reached the following lea	rning resu	ts
Professional Competence				
Knowledge	The students are able to explain network algorithms and in particu- to analyze the computational be programming algorithms as we students can distinguish betwe problems.	lar their data structu havior and compu II network algorith	ures. The iting tim ms. Mo	ey are abl e of linea reover th
Skills	The students are able to analyze possibilities to transform them in they can efficiently implement be LP- and network algorithms and it able to distinguish between different able to use them appropriately.	to networking algo asic algorithms and dentify possible wea	rithms. Ir I data st aknesses	n particula ructures o s. They ar
Personal Competence				
Social Competence	The students have the skills to so and to present the achieved result			
Autonomy	The students are able to retrieve literature and to combine them wi the lecture they can check their a given exercises and test questic learning process.	th the topics of the I bilities and knowled	ecture. ٦ dge on t	hroughoune basis of
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement				
	Written exam			
Examination duration and scale	90 min			

Assignment for the	e Electrical Engineering: Specialisation Modeling and Simulation: Elective Compulsory							
Following Curricula	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory							
-	Theoretical	Mechanical	Engineering:	Specialisation	Numerics	and	Computer	Science:
	Elective Cor	npulsory						

Course L0120: Efficier	nt Algorithms	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	ependent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Siegfried Rump	
Language	DE	
Cycle	WiSe	
Content	 Linear Programming Data structures Leftist heaps Minimum spanning tree Shortest path Maximum flow NP-hard problems via max-cut 	
Literature	 R. E. Tarjan: Data Structures and Network Algorithms. CBMS 44, Society for Industrial and Applied Mathematics, Philadelphia, PA, 1983. Wesley, 2011 http://algs4.cs.princeton.edu/home/ V. Chvátal, ``Linear Programming'', Freeman, New York, 1983. 	

Course L1207: Efficier	Course L1207: Efficient Algorithms		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Siegfried Rump		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses					
Title			Тур	Hrs/wk	СР
Matrix Algorithms (L0984) Matrix Algorithms (L0985)			Lecture Recitation Section (small)	2	3 3
Module Responsible	Dr. Jong Potor Zomk			_	0
Admission		5			
Requirements	None				
Recommended Previous Knowledge		I - III athematics 1/ Numerics dge of the programming la	nguages Matlab and C	;	
Educational Objectives	After taking part succ	essfully, students have rea	ached the following lear	rning resul	ts
Professional Competence					
Competence	Students are able to				
Knowledge	the core prob of linear syste	and classify state-of-the-ar lems of the engineering sc ems, and model reduction; hes for the solution of mate	ciences, namely, eigenv	value prob	lems, solutio
	Students are capable	e to			
Skills	problems, lin 2. assess metho domain of ap	nd assess basic Krylov sub ear systems, and model rea ods used in modern softwa plicability; proaches learned to new, u	duction; are with respect to comp	outing time	C C
Personal Competence					
Competence	Students can				
Social Competence	 form groups applicability; 	document joint solutions in to further develop the o develop, build, and adva	ideas and transfer th	nem to ot	her areas
	Students are able to				
Autonomy	 correctly asse assess wheth individually o define test pr 	ess the time and effort of se her the supporting theoreti r in a team; oblems for testing and expandividual progess and, if n	ical and practical exce anding the methods;		
Workload in Hours	Independent Study 7	ime 124, Study Time in Le	cture 56		
Credit points	6				
Course achievement	None				
Examination					
Examination duration					

Assignment for the Following Curricula Following Curricula

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 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	

Module M0739: F	actory Planning & Product	ion Logistics				
Courses						
Title Factory Planning (L1445)	10	Typ Lecture	Hrs/wk 3	CP 3		
Production Logistics (L14	⁴⁶⁾ Prof. Jochen Kreutzfeldt	Lecture	2	3		
Admission Requirements						
Recommended Previous Knowledge	Bachelor degree in logistics					
Educational Objectives	After taking part successfully, studen	ts have reached the follow	ing learning resul	lts		
Professional Competence						
	The students will acquire the followir 1. The students know the latest trend		e planning of facto	ories.		
Knowledge	2. The students can explain basic procedures of factory planning and are able to deploy these procedures while considering different conditions.					
	3. The students know different methods of factory planning and are able to deal critically with these methods.					
	The students will acquire the followir 1. The students are able to analyze new development and the need for c	factories and other mater	•	with regard		
Skills	2. The students are able to plan and redesign factories and other material handling systems.					
	 The students are able to develop material flow systems. 	procedures for the imple	ementation of nev	w and revise		
Personal Competence						
	The students will acquire the followir 1. The students are able to develop existing material flow systems within	plans for the developme	ent of new and in	nprovement		
Social Competence	2. The developed planning proposa together.	I from the group work can	be documented a	and presente		
	3. The students are able to derive suggestions for improvement from the feedback on the planning proposals and can even provide constructive criticism themselves.					
	The students will acquire the followir 1. The students can plan and re- procedures.			ting plannir		
Autonomy	2. The students can evaluate ind techniques for factory planning and c					
	 The students are able to carry out flow systems. 	autonomously new plans	and transformatic	ons of materi		
	<u> </u>					

Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Logistics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory

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

	3 Independent Study Time 62, Study Time in Lecture 28 DiplIng. Arnd Schirrmann DE
Workload in Hours Lecturer Language	Independent Study Time 62, Study Time in Lecture 28 DiplIng. Arnd Schirrmann DE WiSe • Introduction: situation, significance and main innovation focuses of logistics in production company, aspects of procurement, production, distribution and dispos
Lecturer Language	DiplIng. Arnd Schirrmann DE WiSe • Introduction: situation, significance and main innovation focuses of logistics in production company, aspects of procurement, production, distribution and dispos
Language	 DE WiSe Introduction: situation, significance and main innovation focuses of logistics in production company, aspects of procurement, production, distribution and dispose
	 WiSe Introduction: situation, significance and main innovation focuses of logistics in production company, aspects of procurement, production, distribution and dispose
Cycle	 Introduction: situation, significance and main innovation focuses of logistics in production company, aspects of procurement, production, distribution and dispo-
	production company, aspects of procurement, production, distribution and dispos
Content	 Logistics, production strategy: logistics-oriented method of working in a facto throughput time, corporate strategy, structured networking, reducing complexintegrated organization, integrated product and production logistics (IPPL) Logistics-compatible production and process structuring; logistics-compatible production and organizational structures Logistics-oriented production control: situation and development tendencies, logisticand cybernetics, market-oriented production planning, control, monitoring, Pl systems and production control, cybernetic production organization and contribution logistics concept, computerized aids to planning production logistics, IPPL function economic efficiency of logistics projects Production logistics controlling: production logistics and controlling, material flooriented cost transparency, cost controlling (process cost accounting, costs model IPPL), process controlling (integrated production system, methods and too MEPOT.net method portal)

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Module M0603: N	onlinear Structural Analy	sis		
	-			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Structural Analy		Lecture	3	4
Nonlinear Structural Analy	sis (L0279)	Recitation Section (small)	1	2
Module Responsible	Prof. Alexander Düster			
Admission Requirements	None			
Recommended Previous Knowledge	Knowledge of partial differential eq	uations is recommended.		
Educational Objectives	After taking part successfully, stude	ents have reached the following lea	rning resu	lts
Professional Competence				
Knowledge	Students are able to + give an overview of the different nonlinear phenomena in structural mechanics.			
Skills	 Students are able to + model nonlinear structural problems. + select for a given nonlinear structural problem a suitable computational procedure. + apply finite element procedures for nonlinear structural analysis. + critically verify and judge results of nonlinear finite elements. + to transfer their knowledge of nonlinear solution procedures to new problems. 			
Personal Competence				
Social Competence	Students are able to + solve problems in heterogeneous groups and to document the corresponding results. + share new knowledge with group members.			
Autonomy	Students are able to + acquire independently knowledge to solve complex problems.			
Workload in Hours	Independent Study Time 124, Stud	y Time in Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 min			
-	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Ship and Offshore Technology: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory			

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Course L0277: Nonline	ear Structural Analysis		
Тур	Lecture		
Hrs/wk	3		
СР			
Workload in Hours	ndependent Study Time 78, Study Time in Lecture 42		
Lecturer	Prof. Alexander Düster		
Language	DE/EN		
Cycle	WiSe		
Content	 Introduction Nonlinear phenomena Mathematical preliminaries Basic equations of continuum mechanics Spatial discretization with finite elements Solution of nonlinear systems of equations Solution of elastoplastic problems Stability problems 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: Nonline	urse 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		



Courses					
Title			Тур	Hrs/wk	СР
3D Computer Vision (L012			Lecture	2	3
3D Computer Vision (L01	30)		Recitation Section	on (small) 2	3
Module Responsible		ner Grigat			
Admission Requirements	None				
Recommended Previous Knowledge	 Knowlege of the modules Digital Image Analysis and Pattern Recognition and Data Compression are used in the practical task Linear Algebra (including PCA, SVD), nonlinear optimization (Levenberg-Marquardt) basics of stochastics and basics of Matlab are required and cannot be explained in detail during the lecture. 				
Educational Objectives	Attor taking n	art successfully, stu	dents have reached the follow	wing learning resu	ults
Professional Competence					
Knowledge	Students can	explain and describ	e the field of projective geon	netry.	
Skills	 Using Identif Devel With assistant areas (modult Digitation Pattertand 	highly sophisticated ying problems and oping and impleme ce from the teacher es) Image Analysis n Recognition and I mputer Vision	ary 3D or volumetric analysis d methods and procedures o nting creative solution sugge r students are able to link t Data Compression	f the subject area estions.	e three subje
Personal Competence					
Social Competence	Students can collaborate in a small team on the practical realization and testing of a system reconstruct a three-dimensional scene or to evaluate volume data sets.				
Autonomy	Students are able to solve simple tasks independently with reference to the contents of th lectures and the exercise sets. Students are able to solve detailed problems independently with the aid of the tutorial programming task.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration	60 Minuton C	antant of Lastura a	nd materials in StudIP		

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

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

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

Module M0629: Intelligent Autonomous Agents and Cognitive Robotics

Courses				
Title		Тур	Hrs/wk	СР
	ents and Cognitive Robotics (L0341)	Lecture	2	4
Intelligent Autonomous Agents and Cognitive Robotics (L0512) Recitation Section (small) 2		2	2	
Module Responsible	Rainer Marrone			
Admission Requirements	None			
Recommended Previous Knowledge	Vectors, matrices, Calculus			
Educational Objectives	After taking part successfully, students ha	ave reached the following lea	rning resu	lts
Professional				
Competence				
Knowledge	Students can explain the agent abstract and give details about agent design (g main features of environments. The notic in terms of decision problems and algo uncertainty in real-world scenarios, stud employed as a knowledge representati settings. In addition, students can de sequential settings, with and with comp context, students can describe technique problems, and they can recall techniques identify techniques for simultaneous lo techniques for achieving desired states decision making in a multi-agent setting functions, voting protocol, and mechanism	oals, utilities, environments) on of adversarial agent cooper prithms for solving these pro- tents can summarize how Ba- tion and reasoning formalism effine decision making pro- polete access to the state of es for solving (partially obse- s for measuring the value of i calization and mapping, and s. Students can explain coop i in term of different types of m design techniques.	. They car eration can oblems. Fo ayesian ne m in static cedures ir the enviro ervable) Ma nformation d can exp ordination equilibria,	n describe the be discussed r dealing with tworks can be and dynamic n simple and nment. In this arkov decision . Students can blain planning problems and social choice
Skills	Students can select an appropriate scenarios. For simplified agent application optimization techniques. For those networks/dynamic Bayesian networks a Students can also name and apply scenarios. For simple and complex decision policies for concrete settings. In multi- finding different equilibria states, e.g., students will apply different voting protoc	on students can derive decisi applications they can and apply bayesian reasor different sampling techniqu sion making students can co agent situations students w Nash equilibria. For multi-	on trees an also creating for sites for sint mpute the vill apply to agent december of the second cagent december of the secon	nd apply basic ate Bayesian mple queries. nplified agent best action or echniques for cision making
D				
Personal Competence				
Social Competence	Students are able to discuss their solut English	tions to problems with other	s. They co	mmunicate in
Autonomy	Students are able of checking their unde concrete problems	erstanding of complex conce	pts by solv	ing varaints of
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration				
	55 minutes			

and scale	
Assignment for the	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

Course L0341: Intellige	nt Autonomous Agents and Cognitive Robotics
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	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, elements of chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity, independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations 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 Theorem, Direct mechanisms, incentive compatibili
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig Prentice Hall, 2010, Chapters 2-5, 10-11, 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, Cambridge University Press, 2009

Course 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				
	and Digital Filters (L0446) and Digital Filters (L0447)	Typ Lecture Recitation Section (larg	Hrs/wk 3	CP 4 2
Module Responsible				-
Admission Requirements				
Recommended Previous Knowledge	-	and system theory as well as rando ral transforms (Fourier series, F	•	
Educational Objectives	After taking part successfully, stu	udents have reached the following I	earning resu	lts
Professional Competence				
Knowledge	The students know and understand basic algorithms of digital signal processing. They are familiar with the spectral transforms of discrete-time signals and are able to describe and analyse signals and systems in time and image domain. They know basic structures of digital filters and can identify and assess important properties including stability. They are aware of the effects caused by quantization of filter coefficients and signals. They are familiar with the basics of adaptive filters. They can perform traditional and parametric methods of spectrum estimation, also taking a limited observation window into account.			
Skills	The students are able to apply methods of digital signal processing to new problems. The can choose and parameterize suitable filter striuctures. In particular, the can design adaptiv filters according to the minimum mean squared error (MMSE) criterion and develop a			
Personal Competence				
Social Competence	The students can jointly solve sp	pecific problems.		
Autonomy	The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems software tools, clicker system.			
Workload in Hours	Independent Study Time 124, St	tudy Time in Lecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	90 min			
	Electrical Engineering: Specia Compulsory	on Intelligence Engineering: Electiv lisation Control and Power Syste lisation Information and Commun	ems Enginee	ering: Electiv

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



Course L0446: Digital	Signal Processing and Digital Filters
Тур	Lecture
Hrs/wk	
СР	
	Independent Study Time 78, Study Time in Lecture 42 Prof. Gerhard Bauch
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
Literature	 KD. Kammeyer, K. Kroschel: Digitale Signalverarbeitung. Vieweg Teubner. V. Oppenheim, R. W. Schafer, J. R. Buck: Zeitdiskrete Signalverarbeitung. Pearson StudiumAV. W. Hess: Digitale Filter. Teubner. Oppenheim, R. W. Schafer: Digital signal processing. Prentice Hall. S. Haykin: Adaptive filter theory. L. B. Jackson: Digital filters and signal processing. Kluwer. T.W. Parks, C.S. Burrus: Digital filter design. Wiley.

Course L0447: Digital Signal Processing and Digital Filters		
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Gerhard Bauch	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

-				
Courses	Tur		Hrs/wk	СР
/erification Methods (L01)	22) Typ Lect		2	СР 3
Verification Methods (L12	08) Rec	itation Section (small)	2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in numerics			
Educational Objectives	After taking part successfully, students have reache	ed the following lear	ning result	S
Professional Competence				
Knowledge	The students have deeper knowledge of numerical and semi-numerical methods with the goal to compute principally exact and accurate error bounds. For several fundamental problems they know algorithms with the verification of the correctness of the computed result.			
Skills	The students can devise algorithms for several basic problems which compute rigorous error bounds for the solution and analyze the sensitivity with respect to variation of the input data as well.			
Personal Competence				
	The students have the skills to solve problems together in small groups and to present the achieved results in an appropriate manner.			
Autonomy	The students are able to retrieve necessary informations from the giver literature and to combine them with the topics of the lecture. Throughou the lecture they can check their abilities and knowledge on the basis o given exercises and test questions providing an aid to optimize thei learning process.			
Workload in Hours	Independent Study Time 124, Study Time in Lectur	re 56		
Credit points				
Course achievement				
Examination				
Examination duration and scale	30 min			
	Bioprocess Engineering: Specialisation A - G Compulsory Computer Science: Specialisation Intelligence Eng Computer Science: Specialisation Computer and S Computational Science and Engineering: Special Elective Compulsory	gineering: Elective C Software Engineerin	compulsory g: Elective	, Compulsor

Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Process Engineering: Specialisation Process Engineering: Elective Compulsory
Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory

Course L0122: Verification Methods		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Siegfried Rump	
Language	DE	
Cycle	WiSe	
Content	 Fast and accurate interval arithmetic Error-free transformations Verification methods for linear and nonlinear systems Verification methods for finite integrals Treatment of multiple zeros Automatic differentiation Implementation in Matlab/INTLAB Practical applications 	
Literature	Neumaier: Interval Methods for Systems of Equations. In: Encyclopedia of Mathematics and its Applications. Cambridge University Press, 1990 S.M. Rump. Verification methods: Rigorous results using floating-point arithmetic. Acta Numerica, 19:287-449, 2010.	

Course L1208: Verifica	ourse L1208: Verification Methods		
Тур	Typ Recitation Section (small)		
Hrs/wk			
СР	3		
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28		
Lecturer	rof. Siegfried Rump		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0515: Energy Information Systems and Electromobility

Courses				
Title		Тур	Hrs/wk	СР
	II: Operation and Information Systems of Electrical	Lecture	2	4
Power Grids (L1696)			_	
Electro mobility (L1833)		Lecture	2	2
	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Electrical Engineering			
Educational Objectives	After taking part successfully, students have re	eached the following lea	arning resul	ts
Professional				
Competence				
Knowledge	Students are able to give an overview of the electric power engineering in the field of renewable energies. They can explain in detail the possibilities for the integration of renewable energy systems into the existing grid, the electrical storage possibilities and the electric power transmission and distribution, and can take critically a stand on it.			
Skills	With completion of this module the students are able to apply the acquired skills in applications of the design, integration, development of renewable energy systems and to assess the results.			
Personal Competence				
Social Competence	The students can participate in specialized a and represent their own work results in front o		cussions, a	dvance ideas
Autonomy	Students can independently tap knowledge o	f the emphasis of the le	ctures.	
Workload in Hours	Independent Study Time 124, Study Time in L	ecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Energy and Environmental Engineering: Engineering: Elective Compulsory Energy Systems: Specialisation Energy Syste Renewable Energies: Specialisation Wind En Renewable Energies: Specialisation Solar Er Theoretical Mechanical Engineering: Specialis Theoretical Mechanical Engineering: Technic	ms: Elective Compulso nergy Systems: Elective nergy Systems: Elective isation Energy Systems	ry Compulsor Compulsor : Elective C	y ompulsory

ourse L1696: Electric	al Power Systems II: Operation and Information Systems of Electrical Power Grids
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	 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 / asser 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	mobility
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Klaus Bonhoff
Language	DE
Cycle	WiSe
Content	Inhalt (englisch) 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
Litoroturo	Verleeungeunterlagen/leeture material
Literature	Vorlesungsunterlagen/ lecture material

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Module M0640: Stochastics and Ship Dynamics

Courses						
Title Ship Dynamics (L0352) Ship Dynamics (L1620) Statistics and Stochastic F Engineering (L0364)	Processes in Naval Architecure and Ocean	Typ Lecture Recitation Section (small) Lecture	Hrs/wk 2 1 2	CP 3 1 3		
	Prof. Moustafa Abdel-Maksoud					
Admission Requirements						
Recommended Previous Knowledge	 Technical mechanics Linear algebra, analysis, complex num Fluid mechanics 	mbers				
Educational Objectives	After taking part successfully, students have r	reached the following lea	rning resul	ts		
Professional Competence						
Knowledge	application goals and they can describe the procedure of the manoeuvres. - The students are able to give an overview over varius rudder types. They can name criteria in the rudder design. - The students can name computation methods which are used to determine forces and motions in waves.					
	- The students can come up with the equipanoeuvres. The can use and linearise them	٦.				
Skills	 The students are able to determine hydrodynamic coefficients and they can explain their physical meaning. The students can explain how a rudder works and they can explain the physical effects 					
Chine	which can occur. - The students can mathematically describe waves.					
	- The students can explain the mathematically description of harmoncial motions in waves an they can determine them.					
Personal Competence						
Social Competence	- The students can arrive at work results in groups and document them. - The students can discuss in groups and explain their point of view.					
Autonomy	- The students can assess their own strengthes and weaknesses and the define further work steps on this basis.					
Workload in Hours	Independent Study Time 140, Study Time in I	Lecture 70				
Credit points	7					
Course achievement	None					

Examination									
Examination duration and scale	180 min								
		Engineering ure: Compulso		(German	program,	7	semester):	Specialisation	Naval
Assignment for the Following Curricula	Architectu Naval Arc	ure: Compulso chitecture: Cor	ry e qualifica	tion: Comp	oulsory		·	Specialisation	

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			
Cycle	SoSe			
Content	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 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 Schiffstheorie, Technische Universität Hamburg-Harburg, 2014 Abdel-Maksoud, M., Ship Dynamics, Lecture notes, Institute for Fluid Dynamic Ship Theory, Hamburg University of Technology, 2014 Bertram, V., Practical Ship Design Hydrodynamics, Butterworth-Heinemann, Lin House - Jordan Hill, Oxford, United Kingdom, 2000 Bhattacharyya, R., Dynamics of Marine Vehicles, John Wiley & Sons, Canada,1976 Brix, J. (ed.), Manoeuvring Technical Manual, Seehafen-Verlag, Hamburg, 1993 Claus, G., Lehmann, E., Östergaard, C). Offshore Structures, I+II, Springer-Ve Berlin Heidelberg, Deutschland, 1992 Faltinsen, O. M., Sea Loads on Ships and Offshore Structures, Cambridge Unive Press, United Kingdom, 1990 Handbuch der Werften, Deutschland, 1986 Jensen, J. J., Load and Global Response of Ships, Elsevier Science, Oxford, Un Kingdom, 2001 Lewis, Edward V. (ed.), Principles of Naval Architecture - Motion in Waves Controllability, Society of Naval Architects and Marine Engineers, Jersey City, 1989 Lewandowski, E. M., The Dynamics of Marine Craft: Maneuvering and Seakeep World Scientific, USA, 2004 Lloyd, A., Ship Behaviour in Rough Weather, Gosport, Chichester, Sussex, Un Kingdom, 1998 			

Course L1620: Ship Dynamics			
Тур	Recitation Section (small)		
Hrs/wk	Hrs/wk		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Moustafa Abdel-Maksoud		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

ourse L0364: Statisti	cs and Stochastic Processes in Naval Architecure and Ocean Engineering
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Volker Müller
Language	DE
Cycle	WiSe
Content	 descriptive statistics, parameter, criteria for outliers sample, sample space, probability, probability space Bayes method, conditional probability, law of total probability Discrete and continuous random variables Probability distributions mixed and joint random variables and their distribution Characteristics of random variables (expectation, variance, skewness, kurtosis,) (central) limit theorem Stochastic processes Statistical description of seaway, harmonic analysis of seaway narrow-banded Gaussian process, seaway and its characteristics sea- and wind spectra transformation of spectra, transfer function
Literature	 V. Müller, Statistik und Stochastik in der Schiffs- und Meerestechnik, Vorlesungsskript, Institut für Fluiddynamik und Schiffstheorie, Technische Universität Hamburg-Harburg, 2014 W. Blendermann "Grundlagen der Wahrscheinlichkeitsrechnung", Vorlesungsskript, Arbeitsbereich Fluiddynamik und Schiffstheorie, Technische Universität Hamburg-Harburg, 2001 H. W. Coleman, W. G. Steele, Experimentation and Uncertainty Analysis for Engineers, 3rd Edition, John Wiley & Sons, Inc., New York, NY, 2009 ITTC Recommended Procedures and Guidelines, In: Quality Systems Manual, International Towing Tank Conference (ITTC), 2011 F.M. Dekking, C. Kraaikamp, H.P. Lopuhaä, L.E. Meester, A Modern Introduction To Probability and Statistics, Springer, 2005 Springer Handbook of Engineering Statistics, H. Pham (Hrsg.), Springer, 2006 A. Klenke, Wahrscheinlichkeitstheorie, Springer, 2013

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Module M0511: Electricity Generation from Wind and Hydro Power

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Title	to in Encounted Market (1.0011)	Typ	Hrs/wk	СР
	ts in Emerged Markets (L0014)	Project Seminar	1	1
Hydro Power Use (L0013 Wind Turbine Plants (L00		Lecture Lecture	1 2	1 3
Wind Energy Use - Focus	-	Lecture	2	1
Module Responsible				
Admission				
Requirements	None			
	Module: Technical Thermodynamics I,			
	Module: Technical Thermodynamics II,			
Previous Knowledge	Module: Fundamentals of Fluid Mechan	CC		
		65		
Educational Objectives	After taking part successfully, students h	ave reached the following	learning resu	Its
Professional				
Competence				
Knowledge	By ending this module students can explain in detail knowledge of wind turbine particular focus of wind energy use in offshore conditions and can critical comme aspects in consideration of current developments. Furthermore, they are describe fundamentally the use of water power to generate electricity. The students re and explain the basic procedure in the implementation of renewable energy pr countries outside Europe.			omment thes are able ents reproduc
	Through active discussions of various topics within the seminar of the module, stude improve their understanding and the application of the theoretical background and are the able to transfer what they have learned in practice.			
Skills	Students are able to apply the acquired theoretical foundations on exemplary water or win power systems and evaluate and assess technically the resulting relationships in the contex of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outsid Europe with the in principle applied approach in Europe and can apply this procedure of exemplary theoretical projects.			
Personal Competence				
Social Competence	Students can discuss scientific tasks subjet-specificly and multidisciplinary within a seminar			
Autonomy	Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area.			
Workload in Hours	Independent Study Time 110, Study Tim	e in Lecture 70		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration and scale				
	Civil Engineering: Specialisation Structu Civil Engineering: Specialisation Geotec		• •	ry

	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory
	Energy and Environmental Engineering: Specialisation Energy Engineering: Elective
	Compulsory
	International Management and Engineering: Specialisation II. Renewable Energy: Elective
	Compulsory
	International Management and Engineering: Specialisation II. Energy and Environmental
	Engineering: Elective Compulsory
	Product Development, Materials and Production: Specialisation Product Development:
	Elective Compulsory
Following Curricula	Product Development, Materials and Production: Specialisation Production: Elective
	Compulsory
	Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory
	Renewable Energies: Core qualification: Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory
	Process Engineering: Specialisation Environmental Process Engineering: Elective
	Compulsory
	Water and Environmental Engineering: Specialisation Environment: Compulsory
	Water and Environmental Engineering: Specialisation Cities: Elective Compulsory

Тур	Project Seminar
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
	Prof. Andreas Wiese
Language	DE
Cycle	
Content	 Introduction Development of renewable energies worldwide History Future markets Special challenges in new markets - Overview Sample project wind farm Korea Survey Technical Description Project phases and characteristics Funding and financing instruments for EE projects in new markets Overview funding opportunitie Overview countries with feed-in laws Major funding programs CDM projects - why, how , examples Overview CDM process Examples Examples Exercise CDM Rural electrification and hybrid systems - an important future market for EE Rural electrification - Introduction Types of Elektrizifierungsprojekten The role of the EEInterpretation of hybrid systems Project example: hybrid system Galapagos Islands Tendering process for EE projects - examples South Africa Brazil Selected projects from the perspective of a development bank - Wesley Urena Varg KfW Development Bank Geothermal Wind or CSP Within the seminar, the various topics are actively discussed and applied to various case: application.

ourse 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. Stephan Heimerl
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



Түр	Lecture
Hrs/wk	
СР	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
	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 offshore wind turbines, representation of the individual system components and the system-technical relationships Foundation engineering, offshore site investigation, presentation of different concept 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 device 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 Betrie Vieweg + Teubner, Stuttgart, 2007, 7. Auflage Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-ber 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 d Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage

Courses				
Fitle		Тур	Hrs/wk	СР
Aircraft Systems I (L0735) Aircraft Systems I (L0739)		Lecture Recitation Section (large)	3	4 2
Module Responsible	Prof Frank Thiologka	ricolitation ecotion (large)	L	L
A dmission				
Requirements	None			
	Basic knowledge in:			
	Mathematics			
Recommended	Mechanics			
Previous Knowledge	Thermodynamics Electrical Engineering			
	Electrical EngineeringHydraulics			
	Control Systems			
Educational				
Objectives	After taking part successfully, students h	have reached the following lea	rning resul	ts
Professional				
Competence				
	Students are able to:			
	Describe essential components	s and design points of hydrau	ulic, electri	cal and hig
	lift systemsGive an overview of the function	ality of air conditioning system	c	
Knowledge	 Explain the need for high-lift sys 			
	Assess the challenge during the	e design of supply systems of a	n aircraft	
	Studente ero oble to:			
	Students are able to:			
	Design hydraulic and electric su			
Skills	 Design high-lift systems of aircra Analyze the thermodynamic behavior 		ems	
		aviour of an contaitorning syste	21113	
Personal				
Competence				
	Students are able to:			
Social Competence	 Perform system design in group 	s and present and discuss res	ults	
	Students are able to:			
Autonomy				
, leterieriy	Reflect the contents of lectures a	autonomously		
Workload in Hours	Independent Study Time 110, Study Tin	ne in Lecture 70		
Credit points	δ			
Course achievement	None			

and scale	
	Energy Systems: Specialisation Energy Systems: Elective Compulsory Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective

Course L0735: Aircraf	t Systems I
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

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



Module	M0812:	Aircraft	Design

Courses			
Title	Тур	Hrs/wk	СР
Aircraft Design I (L0820)	Lecture	2	2
Aircraft Design I (L0834)	Recitation Section (lar	ge) 1	1
UAV) (L0844)	tual Design of Rotorcraft, special operations aircraft, Lecture	2	2
Aircraft Design II (Concep UAV) (L0847)	tual Design of Rotorcraft, special operations aircraft, Recitation Section (lar	ge) 1	1
Module Responsible	Prof. Volker Gollnick		
Admission Requirements	None		
Recommended Previous Knowledge	Bachelor Mech. Eng.Vordiplom Mech. Eng.Module Air Transport Systems		
Educational Objectives	After taking part successfully, students have reached the following	learning resu	lts
Professional Competence			
Knowledge	 Principle understanding of integrated aircraft design Understanding of the interactions and contributions of the v Impact of the relevant design parameter on the aircraft design Introduction of the principle design methods 	•	nes
	Understanding and application of design and calculation methods		
Skills	Understanding of interdisciplinary and integrative interdependenc		
Personal Competence			
	Working in interdisciplinary teams		
Social Competence	Communication		
Autonomy	Organization of workflows and -strategies		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	120 min		
_	Aircraft Systems Engineering: Core qualification: Compulsory International Management and Engineering: Specialisation II. Compulsory Product Development, Materials and Production: Specialisat Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary C Theoretical Mechanical Engineering: Specialisation Aircraft Sys Compulsory	ion Product ourse: Electiv	Developmen e Compulsory

Course L0820: Aircraf	t Design I
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Volker Gollnick
Language	DE
Cycle	WiSe
Content	 geometry) 7. Principles of engine design and integration 8. Cruise design 9. Design of runway and landing field length 10. Cabin design (fuselage dimensioning, cabin interior, loading systems) 11. System- and equipment aspects 12. Design variations and operating cost calculation
Literature	J. Roskam: "Airplane Design" D.P. Raymer: "Aircraft Design - A Conceptual Approach" J.P. Fielding: "Intorduction to Aircraft Design" Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design"

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

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

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

Module M1037: Engineering	Steam Turbines in Energy,	Environmental	and Po	wer Train
Courses				
Title Steam turbines in energy, (L1286)	, environmental and Power Train Engineering	Typ Lecture	Hrs/wk 3	CP 5
Steam turbines in energy, (L1287)	, environmental and Power Train Engineering	Recitation Section (sm	all) 1	1
Module Responsible	Prof. Alfons Kather			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully students have	reached the following I	learning resu	lts
Professional Competence				
Knowledge	 calculate thermodynamically a turbin calculate or estimate and further eval outline diagrams describing the oper investigate the constructive asperequirements the required construction discuss and argue on the operation of evaluate thermodynamically the integral 	and constructive groups ng conditions for the ap and differentiate among cesses and the con- er e stage and a stage as luate sections of the tur ating range and the co- ects and develop on characteristics characteristics of differe- gration of different turbi	s of steam turk oplication of s g steam turbi ustructive and ssembly rbine nstructive cha from the th ent turbine typ ine designs in	steam turbines nes according d operational aracteristics hermodynamic bes n heat cycles.
Skills	 In the module the students learn the fundam operational evaluation of complex plant, optimisations. They specifically: obtain the ability to analyse the poter thermodynamically, from the energetiener explanate the performance and sources, for supplying base load and on the basis of the impact of power prodescribe the precautionary principles can describe the key requirements for Plants, based on the overriding demandant. 	and gain in particul ntial of various energy ic-economic and techn d technical limitations l balancing reserve pov plant operation on the in s for damage preventio or the Management and	lar confidence sources that of ical viewpoin in using va wer to the ele- ntegrity of cor n d Design of T	ce in seeking can be utilised its arious energy ctricity grid mponents, can Thermal Power
Personal Competence				

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	In the module the students learn:
Social Competence	 to work together with others whilst seeking a solution to assist each other in problem solving to conduct discussions to present work results to work respectfully within the team.
Autonomy	In the module the students learn the independent working of a complex theme whilst considering various aspects. They also learn how to combine independent functions in a system. The students become the ability to gain independently knowledge and transfer it also to new problem solving.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
	Written exam
Examination duration and scale	180 min
-	Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1286: Steam	turbines in energy, environmental and Power Train Engineering
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
	 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

Content	 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 gas 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 manufacturing 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
Literature	 Traupel, W.: Thermische Turbomaschinen. Berlin u. a., Springer (TUB HH: Signatur MSI-105) Menny, K.: Strömungsmaschinen: hydraulische und thermische Kraft- und Arbeitsmaschinen. Ausgabe: 5. Wiesbaden, Teubner, 2006 (TUB HH: Signatur MSI-121) Bohl, W.: Aufbau und Wirkungsweise. Ausgabe 6. Würzburg, Vogel, 1994 (TUB HH: Signatur MSI-109) Bohl, W.: Berechnung und Konstruktion. Ausgabe 6. Aufl. Würzburg, Vogel, 1999 (TUB HH: Signatur MSI-110)

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
Electrical Installation on Sh	nips (L1531)	Lecture	2	2
Electrical Installation on Sh		Recitation Section		1
Marine Engineering (L1569 Marine Engineering (L1570		Lecture Recitation Section	2 (larga) 1	2 1
	Prof. Christopher Friedrich Wirz	necitation Section	(large) i	I
Admission	None			
Requirements Recommended				
Previous Knowledge Educational	After taking part successfully, stud	ents have reached the followi	ng learning res	ults
Objectives Professional Competence				
Knowledge	components on ships and apply optimize the interaction of the co- complex correlations with the spe- are able to name the operating be design of supply networks and onboard ships, offshore units, fact generation and distribution in iso requirements for network protection	omponents of the propulsion cific technical terms in Germ haviour of consumers, descri to the electrical equipment ories and emergency power plated grids, wave generator	system and h an and English be special requi in isolated ne supply systems systems on sh	ow to describ . The studen irements on th tworks, as e. , explain pow
Skills	The students are skilled to emp machinery, their selection and o analyse and solve technical and and to design propulsion syste correlations and bring them into con- short-circuit currents, switchgear, a	peration on board ships. Th operational problems with p ms. The students have the ontext with related disciplines	ey are further a ropulsion and e skills to des . Students are a	able to asses auxiliary plan scribe comple ble to calcula
	The students are able to commu shipbuilding and component supp		ofessional envi	ironment in th
	The widespread scope of gained future profession independently a	-	nts to handle si	tuations in the
Workload in Hours	Independent Study Time 96, Study	/ Time in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration	90 minutes plus 20 minutes oral e			

Assignment for the
Following CurriculaEnergy Systems: Specialisation Marine Engineering: CompulsoryTheoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L1531: Electric	cal Installation on Ships
Тур	Lecture
Hrs/wk	2
СР	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: Electric	cal 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 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

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Elective Compulsory Compulsory Specialisation II. Avia	y ation System	s: Electiv
	Elective Compulsor Compulsory Specialisation II. Avi	and Power Systems Engineerin Elective Compulsory Compulsory Specialisation II. Aviation System

Compul	sory						
Product	Development,	Materials	and	Production:	Specialisation	Materials:	Elective
Compul	sory						
Theoret	ical Mechanical	Engineering	g: Spe	cialisation Ai	rcraft Systems I	Engineering:	Elective
Compul	sory						
Theoret	ical Mechanical E	ingineering	Tech	nical Compler	mentary Course:	Elective Cor	npulsory

Course L1545: Aircraf	t Cabin Systems
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	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 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 Systems		
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

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Module M1157: M	larine Auxiliaries					
Courses						
Title		Tun		CD		
Electrical Installation on SI Electrical Installation on SI Auxiliary Systems on Boa Auxiliary Systems on Boa	Typ Lecture Recitation Section (large) Lecture Recitation Section (large)	2	CP 2 1 2 1			
Module Responsible	Prof. Christopher Friedrich Wirz					
Admission Requirements	· · · · · · · · · · · · · · · · · · ·					
Recommended Previous Knowledge						
Educational Objectives	After taking part successfully, student	s have reached the following lea	arning resu	lts		
Professional Competence						
Knowledge	 The students are able to name the operating behaviour of consumers, describe special requirements on the design of supply networks and to the electrical equipment in isolated networks, as e.g. onboard ships, offshore units, factories and emergency power supply systems, explain power generation and distribution in isolated grids, wave generator systems on ships, name requirements for network protection, selectivity and operational monitoring, name the requirements regarding marine equipment and apply to product development, as well as describe operating procedures of equipment components of standard and specialized ships and derive requirements for product development. Students are able to calculate short-circuit currents, switchgear, 					
Skills	 design electrical propulsion systems for ships design additional machinery components, as well as to apply basic principles of hydraulics and to develop hydraulic systems. 					
Personal Competence						
Social Competence	The students are able to communicate and cooperate in a professional environment in the shipbuilding and component supply industry.					
Autonomy	The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently.					
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84					
Credit points						
Course achievement	None					
Examination	l					
Examination duration and scale	20 min					
	Naval Architecture and Ocean Engine	eering: Core qualification: Electi	ve Compul	sory		

Assignment for the Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Following Curricula Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory

Course L1531: Electric	cal Installation 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: Electric	Course 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: Auxilia	ry 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: Auxilia	Course L1250: Auxiliary Systems on Board of Ships				
Тур	Typ 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					
	Siehe korrespondierende Vorlesung				
Literature					

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Module M1146: S	Ship Vibration			
Courses				
Title Ship Vibration (L1528) Ship Vibration (L1529)	Typ Lecture Recitation Section (sma	Hrs/wk 2 all) 2	CP 3 3	
Module Responsible	Dr. Rüdiger Ulrich Franz von Bock und Polach			
Admission Requirements	None			
Recommended Previous Knowledge	Mechanis I - III Structural Analysis of Ships I Fundamentals of Ship Structural Design			
Educational Objectives	After taking part successfully, students have reached the following l	earning resu	lts	
Professional Competence				
Knowledge	Students can reproduce the acceptance criteria for vibrations on ships; they can explain the methods for the calculation of natural frequencies and forced vibrations of sructural components and the entire hull girder; they understand the effect of exciting forces of the propeller and main engine and methods for their determination			
Skills	Students are capable to apply methods for the calculation of natural frequencies and exciting forces and resulting vibrations of ship structures including their assessment; they can mode structures for the vibration analysis			
Personal Competence				
Social Competence	The students are able to communicate and cooperate in a profe shipbuilding and component supply industry.	ssional envir	onment in the	
Autonomy	Students are able to detect vibration-prone components on ships select suitable calculation methods and to assess the results	, to model th	ne structure, t	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement				
	Written exam			
Examination duration and scale	13 hours			
_	Energy Systems: Specialisation Marine Engineering: Elective Comp Naval Architecture and Ocean Engineering: Core qualification: Com Ship and Offshore Technology: Core qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Maritim Compulsory Theoretical Mechanical Engineering: Technical Complementary Co	npulsory le Technolo		

Course L1528: Ship Vil	bration
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	 Introduction; assessment of vibrations Basic equations Beams with discrete / distributed masses Complex beam systems Vibration of plates and Grillages Deformation method / practical hints / measurements Hydrodynamic masses Spectral method Hydrodynamic masses acc. to Lewis Damping Shaft systems Propeller excitation Engines
Literature	Siehe Vorlesungsskript

Course L1529: Ship Vi	bration
Тур	Recitation Section (small)
Hrs/wk	2
CP	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	 Introduction; assessment of vibrations Basic equations Beams with discrete / distributed masses Complex beam systems Vibration of plates and Grillages Deformation method / practical hints / measurements Hydrodynamic masses Spectral method Hydrodynamic masses acc. to Lewis Damping Shaft systems Propeller excitation Engines
Literature	Siehe Vorlesungsskript



0						
Courses Title				Тур	Hrs/wk	СР
Mathematical Image Processing (L0991)				Lecture	3	4
Mathematical Image Processing (L0992) Recitation Section (small) 1					2	
Module Responsible		rko Lindner				
Admission Requirements	None					
Recommended Previous Knowledge		• •	-	directional derivative uares solution of a linear	rsystem	
Educational Objectives	Attor tok	ing part successfully	v, students have r	eached the following lea	Irning resu	lts
Professional Competence						
Knowledge	• c • e • e	 Students are able to characterize and compare diffusion equations explain elementary methods of image processing explain methods of image segmentation and registration sketch and interrelate basic concepts of functional analysis 				
Skills	 Students are able to implement and apply elementary methods of image processing explain and apply modern methods of image processing 					
Personal Competence						
Social Competence	Students are able to work together in heterogeneously composed teams (i.e., teams fror different study programs and background knowledge) and to explain theoretical foundations.					
Autonomy	c ti • S	own. They can speci hem.	fy open questions	eir understanding of co s precisely and know wh ersistence to be able to v ems.	ere to get l	nelp in solvii
Workload in Hours	Indepen	dent Study Time 12	4, Study Time in I	_ecture 56		
Credit points	6					
Course achievement	None					
Examination		ım				
Examination duration and scale	20 min					
Assignment for the Following Curricula	Compute Compute Electrica Compute Mechatre Technor Theoreti	sory er Science: Speciali al Engineering: Spec ational Science and onics: Technical Co nathematics: Specia	sation Intelligenc sialisation Modeli Engineering: Sp mplementary Cou lisation I. Mather	- General Bioprocess e Engineering: Elective (ng and Simulation: Elect ecialisation III. Mathemat urse: Elective Compulso natics: Elective Compuls cialisation Numerics a	Compulsor ive Compu tics: Electiv ry ory	y ilsory re Compulso



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 M1020: N	Iumerics of Partial Diffe	rential Equations		
Courses				
Title Numerics of Partial Differe Numerics of Partial Differe		Typ Lecture Recitation Section (s	Hrs/wk 2 small) 2	CP 3 3
	Prof. Sabine Le Borne			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	Attor taking part successfully sti	idents have reached the following	g learning resu	lts
Professional Competence				
Knowledge	 For each type, students k 	tial differential equations accordi now suitable numerical approac etical convergence results for the	hes.	
Skills	Students are capable to formulate solution strategies for given problems involving partial differential equations, to comment on theoretical properties concerning convergence and to implement and test these methods in practice.			
Personal Competence				
Social Competence	Students are able to work togo different study programs and bac	ether in heterogeneously comp ckground knowledge) and to exp		
Autonomy	 Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. 			
Workload in Hours	Independent Study Time 124, St	udy Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination				
Examination duration and scale	25 min			
_	Computational Science and Engineering: Specialisation Scientific Computing: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory			

Course L1247: Numer	ics of Partial Differential Equations
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
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: Numer	ourse L1248: Numerics of Partial Differential Equations	
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	NN	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

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Courses				
Title Integrated Product Develo	opment II (L1254)	Typ Lecture	Hrs∕wk 3	СР 3
Integrated Product Develo	opment II (L1255)	Project-/problem-based Learning	2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of Integrated produ	ict development and applying CA	AE systems	
Educational Objectives	After taking part successfully, studen	ts have reached the following lea	arning resu	lts
Professional Competence				
Competence	After passing the module students ar	e able to:		
Knowledge	 explain technical terms of des describe essential elements of 	sign methodology,	ch of integ	ırated produ
Skills	 select and apply proper construction methods for non-standardized solutions of problems as well as adapt new boundary conditions, solve product development problems with the assistance of a workshop base approach, choose and execute appropriate moderation techniques. 			
Personal Competence		a abla ta i		
Social Competence	After passing the module students ar prepare and lead team meeti work in teams on complex tas represent problems and solution 	ngs and moderation processes, sks,		
Autonomy	After passing the module students ar • give a structured feedback ar • implement the accepted feed	nd accept a critical feedback,		
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	L30 Minuten			
	Aircraft Systems Engineering: Specia Aircraft Systems Engineering: Specia International Management and En Production: Elective Compulsory	alisation Air Transportation Syste	ms: Electiv	e Compulsor

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



Course L1254: Integrat	ted Product Development II
Тур	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	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
Literature	 under its own planning and management. 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 und 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

Course L1255: Integra	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	

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Module M0867: F	Production Planning & Con	trol and Digital Ente	erprise	
		-	•	
Courses				
Title		Тур	Hrs/wk	СР
The Digital Enterprise (L0		Lecture	2	2
Production Planning and (Lecture	2	2
Production Planning and C Exercise: The Digital Enter		Recitation Section Recitation Section		1 1
_		Recitation Section	(Smail) i	I
	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Production and Qu	ality Management		
Educational Objectives	Attar taking part successfully studen	its have reached the followi	ng learning resul	ts
Professional Competence				
•		the module in detail and ta	ke a critical posit	ion to them
Skills	Students can explain the contents of the module in detail and take a critical position to them. Students are capable of choosing and applying models and methods from the module to			
Personal	industrial problems.			
Competence				
Social Competence	Students can develop joint solutions	in mixed teams and preser	nt them to others.	
Autonomy	- -			
Workload in Hours	Independent Study Time 96, Study T	ime in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
	International Management and En	igineering: Specialisation	II. Product Deve	elopment and
	Production: Elective Compulsory	lity Specialization Brody	otion and Logic	tion: Elective
	Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective			
	Compulsory			- .
	Biomedical Engineering: Specialisat Biomedical Engineering: Specialisat			• •
	Compulsory	allon medical recimology		
Assignment for the Following Curricula	Biomedical Engineering: Specia	lisation Management ar	nd Business A	dministration
Following Curricula	Compulsory			
	Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory			
	Product Development, Materials and Production: Specialisation Production: Compulsory			
	Product Development, Materials and Production: Specialisation Materials: Elective			
	Compulsory			
	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory			
	Theoretical Mechanical Engineering	: Technical Complementary	Course: Elective	e Compulsory

Course L0932: The Digital Enterprise		
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 Planning 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: Produc	tion 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		

Module M0815: P	Product Planning						
	roddot i laining						
Courses							
Title			ур	Hrs/wk	СР		
Product Planning (L0851)			roject-/problem-based earning	3	3		
Product Planning Seminar (L0853)			roject-/problem-based earning	2	3		
Module Responsible	Prof. Cornelius Herstatt						
Admission Requirements	I None						
Recommended Previous Knowledge	Good basic-knowledge of Business Administration						
Educational Objectives	After taking part successfully, students have reached the following learning results						
Professional Competence							
Knowledge	 Product Planning Process Methods Design thinking Process Methods User integration 	ation					
Skills	 Students will gain deep insights into: Product Planning Process-related aspects Organisational-related aspects Human-Ressource related aspects Working-tools, methods and instruments 						
Personal							
Competence Social Competence	 Interact within a team 						
Autonomy	 Gain access to knowledge sources Interpret complex cases Develop presentation skills 						
Workload in Hours	Independent Study Time 1	10, Study Time in Lec	ture 70				
Credit points							
Course achievement	Compulsory Bonus Yes 20 %	Form Subject theoretic	Description al and	on			
Eveningtion		practical work					
Examination Examination duration	Written exam 90 minutes						

TUHH Hamburg University of Technolog

Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0851: Produc	t Planning
Тур	Project-/problem-based Learning
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.
Literature	Ulrich, K./Eppinger, S.: Product Design and Development, 2nd. Edition, McGraw-Hill 2010

Course L0853: Produc	Course 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/siehe Vorlesung Produktplanung/Product Planning				

Courses				
Title Fluidics (L1256)		Typ Lecture	Hrs/wk 2	СР 3
Fluidics (L1371)		Project-/problem-based Learning	1	2
Fluidics (L1257)		Recitation Section (large)	1	1
Module Responsible Admission				
Requirements Recommended	None Good knowledge of mechanics (stereo kinetics), fluid mechanics, and engineerir	-	ostatics, k	inematics and
Educational Objectives	After taking part successfully, students ha		arning resu	Its
Professional Competence				
Knowledge	 explain open and closed loop control of hydraulic systems, describe functioning and applications of hydrodynamic torque converters, brakes and clutches as well as centrifugal pumps and aggregates in plant technology 			
Skills	 After passing the module students are ab analyse and assess hydraulic and design and dimension hydraulic s perform numerical simulations definitions, select and adapt pump characteris dimension hydrodynamic torque of 	l pneumatic components an ystems for mechanical appli of hydraulic systems base stic curves for hydraulic syst	cations, ed on abs ems	·
Personal Competence	After passing the module students are ab	le to		
Social Competence	 discuss and present functional col organise teamwork autonomously 	ntext in groups,		
Autonomy	After passing the module students are ab obtain necessary knowledge for the 			
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		

	Yes	None	Attestation	Systeme	
	Written exam				
Examination duration and scale	90				
Assignment for the Following Curricula	Compulsory International Production: E Product Dev Compulsory Product Dev Compulsory Product De Compulsory Theoretical M Elective Com	Managemen Elective Comp velopment, M velopment, velopment, Mechanical E apulsory	nt and Engine bulsory Materials and Materials and Materials and Engineering: Sp	neering: Specialisation II. Mechati ering: Specialisation II. Product De Production: Specialisation Produc Production: Specialisation Produc d Production: Specialisation Mat pecialisation Product Development	evelopment and t Development: uction: Elective erials: Elective and Production:

Course L1256: Fluidics	3
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Dieter Krause
Language	
Cycle	WiSe
	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 interoperation of motor and transmission
	Exercise
Content	 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 Bücher Murrenhoff, H.: Grundlagen der Fluidtechnik - Teil 1: Hydraulik, Shaker Verlag, Aachen, 2011 Murrenhoff, H.: Grundlagen der Fluidtechnik - Teil 2: Pneumatik, Shaker Verlag,
Literature	 Matheman, M.: Grandiagen der Haldtechnik – Feir Z. Friedmatik, Onaker 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		
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	

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

Module M0806: T	echnical Acoustics II (Room Aco	oustics, Computat	ional Me	ethods)
Courses				
	oom Acoustics, Computational Methods) (L0519) oom Acoustics, Computational Methods) (L0521)	Typ Lecture Recitation Section (large)	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous Knowledge	Technical Acoustics I (Acoustic Waves, Noise Mechanics I (Statics, Mechanics of Materia Dynamics) Mathematics I, II, III (in particular differential e	uls) and Mechanics II (H		s, Kinematics
Educational Objectives	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 to give an overview of the corresponding theoretical and methodical basis.			
Skills	The students are capable to handle engin application of the demanding computation module.			
Personal Competence				
Social Competence	Students can work in small groups on specific	c problems to arrive at joi	int solution:	S.
Autonomy	The students are able to independently solve treated within the module. Possible conflicting results are critically scrutinized.		•	
Workload in Hours	Independent Study Time 124, Study Time in I	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	20-30 Minuten			
-	Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production Elective Compulsory			

Course L0519: Technie	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) 			
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: Technie	urse 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		



	Тур	Hrs/wk	СР		
-	Lecture	2	3		
ercise (L1534)	Recitation Section (small)	2	3		
None					
moments, stress, linear strain, free-body					
After taking part successfully, students have	reached the following lea	rning results	5		
The students can explain the fundamental concepts to calculate the mechanical behavior of materials.					
		nation theor	y to speci		
The students are able to develop solutions	to present them to special	iete in writter	form and		
The students are able to develop solutions, to present them to specialists in written form and develop ideas further.					
independently and on their own identify	and solve problems in		-		
Independent Study Time 124, Study Time in	n Lecture 56				
6					
None					
45 min					
Mechanical Engineering and Management: Mechatronics: Technical Complementary C Biomedical Engineering: Specialisation Arti Compulsory Biomedical Engineering: Specialisation Imp	Specialisation Materials: I ourse: Elective Compulsor ificial Organs and Regene plants and Endoprostheses	y rative Medic s: Elective C	sine: Electiv		
	moments, stress, linear strain, free-body energy). After taking part successfully, students have The students can explain the fundamental materials. The students can set up balance laws and aspects, both in applied contexts as in rese The students are able to develop solutions, develop ideas further. The students are able to assess their independently and on their own identify mechanics and acquire the knowledge requind Independent Study Time 124, Study Time in 6 None Written exam 45 min Materials Science: Specialisation Modeling Mechanical Engineering: Specialisation Art Compulsory Biomedical Engineering: Specialisation Imp Biomedical Engineering: Specialisation Imp Biomedical Engineering: Specialisation Imp Biomedical Engineering: Specialisation Imp	Prof. Christian Cyron None Basics of linear continuum mechanics as taught, e.g., in the module I moments, stress, linear strain, free-body principle, linear-elastic energy). After taking part successfully, students have reached the following lea The students can explain the fundamental concepts to calculate the materials. The students can set up balance laws and apply basics of deforn aspects, both in applied contexts as in research contexts. The students are able to develop solutions, to present them to special develop ideas further. The students are able to assess their own strengths and v independently and on their own identify and solve problems in mechanics and acquire the knowledge required to this end. Independent Study Time 124, Study Time in Lecture 56 6 None Written exam 45 min Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials:	533) Lecture 2 prcise (L1534) Recitation Section (small) 2 Prof. Christian Cyron None Basics of linear continuum mechanics as taught, e.g., in the module Mechanics I moments, stress, linear strain, free-body principle, linear-elastic constitutive energy). After taking part successfully, students have reached the following learning results materials. The students can explain the fundamental concepts to calculate the mechanical materials. The students can set up balance laws and apply basics of deformation theor aspects, both in applied contexts as in research contexts. The students are able to develop solutions, to present them to specialists in writter develop ideas further. The students are able to assess their own strengths and weaknesses independently and on their own identify and solve problems in the area o mechanics and acquire the knowledge required to this end. Independent Study Time 124, Study Time in Lecture 56 6 6 Mone Written exam 45 min Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering: Specialisation Artificial Organs and Regenerative Medic Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Con Biomedical Engineering: Specialisation Materials control The		



Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

Course L1533: Contin	uum Mechanics
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	 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

Course L1534: Continuum Mechanics Exercise			
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	 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 Vibration Theory (L0701)	TypHrs/wkIntegrated Lecture4	CP 6
Module Responsible	Prof. Norbert Hoffmann	
Admission Requirements	INONE	
Recommended Previous Knowledge	Inear Algebra	
Educational Objectives	After taking part successfully, students have reached the following learning results	3
Professional Competence		
Knowledge	Students are able to denote terms and concepts of Vibration Theory and develop	them furth
Skills	Students are able to denote methods of Vibration Theory and develop them furthe	r.
Personal Competence		
Social Competence	Students can reach working results also in groups.	
Autonomy	Students are able to approach individually research tasks in Vibration Theory.	
	Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement		
	Written exam	
Examination duration and scale	12 HOURS	
-	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatroni Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medic Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective C Biomedical Engineering: Specialisation Medical Technology and Control The Compulsory Biomedical Engineering: Specialisation Management and Business Administrat Compulsory Product Development, Materials and Production: Core qualification: Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective	Compulse cine: Elect ompulsory ory: Elect tion: Elect pry

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		Tun	Hrs/wk	СР
Advanced Topics in Contr	ol (L0661)	Typ Lecture	2	С г 3
Advanced Topics in Contr	ol (L0662)	Recitation Section	(small) 2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	H-infinity optimal control, mixed-sen	sitivity design, linear matrix	inequalities	
Educational Objectives	After taking part successfully, studer	its have reached the followi	ng learning resu	Its
Professional Competence				
Knowledge	 Students can explain the scheduling approach They can explain the repressystems They can explain how stabiformulated as LMI conditions They can explain how gridsynthesis problems for LPV se They are familiar with polytothe basic synthesis technique Students can explain how communication topology of m They can explain the convergence of the convergence of the second secon	sentation of nonlinear syst lity and performance cond dding techniques can be systems pic and LFT representation es associated with each of t graph theoretic concepts nultiagent systems gence properties of first or and synthesis conditions gent models ate space representation of according to an actuator/sel	tems in the form itions for LPV sy used to solve us of LPV system these model struct s are used to der consensus pr s for formation of spatially invari nsor array counded real le	of quasi-LP vstems can b analysis an s and some of ctures represent th otocols control loop ant distribute
Skills		gain-scheduled controlle V models rd software tools (Matlab ro	ers; they can o	do this usin lbox) for thes
	 Students are able to design either LTI or LPV dynamics, u Students are able to design using the Matlab MD-toolbox 	using Matlab tools provided distributed controllers for sp		-

Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	
Examination duration and scale	30 min
	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Anagement and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Anagement and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory



Course L0661: Advand	ed Topics 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 Control of Spatially Interconnected Systems Multidimensional signals, I2 and L2 signal norm Multidimensional systems in Roesser state space form Extension of real-bounded lemma to spatially interconnected systems LMI-based synthesis of distributed controllers Spatial LPV control of spatially varying systems Applications: control of temperature profiles, vibration damping for an actuated beam
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	

Module M0939: C	Contro	ol Lab A				
Courses						
Title				Тур	Hrs/wk	СР
Control Lab I (L1093)				Practical Course		1
Control Lab II (L1291)				Practical Course		1
Control Lab III (L1665)				Practical Course	e 1	1
Control Lab IV (L1666)				Practical Course	e 1	1
Module Responsible	Prof. H	lerbert Werner				
Admission Requirements	Nono					
Recommended Previous Knowledge		State space meth LQG control H2 and H-infinity uncertain plant n LPV control	/ optimal contr			
Educational Objectives	Atter to	aking part success	sfully, students	have reached the follow	wing learning resu	ilts
Professional Competence						
Knowledge	•	Students can ex and experimenta	•	rence between validati	on of a control lo	p in simulatior
Skills	 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers 					
Personal Competence						
Social Competence	•	Students can wo	ork in teams to	conduct experiments ar	nd document the r	esults
Autonomy	•	Students can inc loops	dependently ca	arry out simulation studi	es to design and	validate contro
Workload in Hours	Indepe	endent Study Time	e 64, Study Tin	ne in Lecture 56		
Credit points	4					
Course achievement						
Examination	<u> </u>	n elaboration				
Examination duration and scale	1					
		cal Engineering:	Specialisatio	n Control and Power	Systems Engine	ering: Elective

Assignment for the
Following CurriculaCompulsory
Mechatronics: Specialisation System Design: Elective Compulsory
Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Theoretical Mechanical Engineering: Core qualification: Elective 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.		
	Experiment Guides		
Literature			

Course L1291: Contro	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 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
	One of the offered experiments in control theory.
Literature	Experiment Guides

Course L1666: Contro	ourse L1666: Control Lab IV	
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	
	One of the offered experiments in control theory.	
Literature	Experiment Guides	

Module M1043: Aircraft Systems Engineering

Title		Тур	Hrs/wk	СР
Fatigue & Damage Tolerance (L0310)		Lecture	2	3
Lightweight Construction with Fibre Reinforced Rolymers - Structural Mechanics (L1514)		Lecture	2	3
Lightweight Design Practic	al Course (L1258)	Project-/problem-based Learning	3	3
Aviation Security (L1549)		Lecture	2	2
Aviation Security (L1550)		Recitation Section (small)	1	1
Mechanisms, Systems and	d Processes of Materials Testing (L0950)	Lecture	2	2
Turbo Jet Engines (L0908))	Lecture	2	3
System Simulation (L1820))	Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Materials Testing (L0949)		Lecture	2	2
Reliability in Engineering Dynamics (L0176)		Lecture	2	2
Reliability in Engineering Dynamics (L1303)		Recitation Section (small)	1	2
Reliability of avionics assemblies (L1554)		Lecture	2	2
Reliability of avionics assemblies (L1555)		Recitation Section (small)	1	1
Reliability of Aircraft Systems (L0749)		Lecture	2	3
Module Responsible				
Admission Requirements	None			
	Basic knowledge in:			
	Mathematics			
Recommended	Mechanics			
necommended	 Thermodynamics 			

Recommended	Mechanics
Previous Knowledge	Inermodynamics
FIEVIOUS KIIOWieuge	 Electrical Engineering
	Hydraulics
	 Control Systems

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 systems engineering, air transportation system and material science 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 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	6

Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory

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

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

Course L1514: Lightweight Construction with Fibre Reinforced Rolymers - Structural Mechanics	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Benedikt Kriegesmann
Language	DE
Cycle	WiSe
	 Fundamentals of Anisotropic Elasticity Displacements, strains and stresses; Equilibrium equations; Kinematics; Hooke's generalized law Behaviour of a single laminate layer Material law of a single laminate layer; Full anisotropy and coupling effects; Material symmetries; Engineering constants; Plane state of stress; Transformation rules Fundamentals of Micromechanics of a laminate layer Representative unit cell; Determination of effective material constants; Effective stiffness properties of a single layer Classical Laminate Plate Theory



	Notations and laminate code; Kinematics and displacement field; Strains and stresses, stress resultants; Constitutive equations and coupling effects; Special laminates and their behavior; Effective laminate properties
Content	Strength of Laminated Plates
	Fundamental concept; Phenomenological failure criteria: maximum stresses, maximum strains, Tsai-Hill, Tsai-Wu, Puck, Hashin
	Bending of Composite Laminated Plates
	Differential Equations; Boundary Conditions; Navier-type solutions; Lévy-type solutions
	Stress Concentration Problems
	Free-edge effects; Stress concentrations at holes, cracks, delaminations; Aspects of failure analysis
	Stability of Thin-Walled Composite Structures
	Buckling of anisotropic plates and shells; Influence of loading conditions; Influence of boundary conditions; Exact transcendental solutions and their evaluation; Buckling of stiffened composite plates; Minimum stiffness requirements; Local buckling of stiffener profiles
	Written exercise (report required)
	Assessment of a thin-walled composite laminated beam taking several different dimensioning criteria into account
	 Schürmann, H., "Konstruieren mit Faser-Kunststoff-Verbunden", Springer, Berlin, aktuelle Auflage. Wiedemann, J., "Leichtbau Band 1: Elemente", Springer, Berlin, Heidelberg, , aktuelle Auflage.
Literature	 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.



Тур	Project-/problem-based Learning	
Hrs/wk		
CP		
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Examination Form	Mündliche Prüfung	
Examination duration and scale	L'AU MIN	
Lecturer	Prof. Dieter Krause	
Language	DE/EN	
Cycle	SoSe	
Content	 getting familiar with fibre reinforced plastics as well as lightweight design Design of a sandwich structure made of fibre reinforced plastics using finite eleme 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, 200 Puck, A., "Festigkeitsanalsyse von Faser-Matrix-Laminaten", Hanser, München, Wie 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 (UF Elsevier, 2005. Krause, D., "Leichtbau", In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, F München, Carl Hanser Verlag, 2012. Schulte, K., Fiedler, B., "Structure and Properties of Composite Materials", Hambur 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 scale	90 Minuten	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	WiSe	
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization. The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization: • Historical development • The special role of air transport • Motive and attack vectors • The human factor • Threats and risk • Regulations and law • Organization and implementation of aviation security tasks • Passenger and baggage checks • Cargo screening and secure supply chain • Safety technologies	
Literature	 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: Aviatio	n Security
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	WiSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization. The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization: • Historical development • The special role of air transport • Motive and attack vectors • The human factor • Threats and risk • Regulations and law • Organization and implementation of aviation security tasks • Passenger and baggage checks • Cargo screening and secure supply chain • Safety technologies
Literature	 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 L0950: Mecha	nisms, Systems and Processes of Materials Testing
	Lecture
Hrs/wk	
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	
Examination duration and scale	90 Minuten
Lecturer	Dr. Jan Oke Peters
Language	DE
Cycle	SoSe
Content	 Application, analysis and discussion of basic and advanced testing methods to ensure correct selection of applicable testing procedure for investigation of part/materials deficiencies Stress-strain relationships Strain gauge application Visko elastic behavior Tensile test (strain hardening, necking, strain rate) Compression test, bending test, torsion test Crack growth upon static loading (J-Integral) Crack growth upon cyclic loading (micro- und macro cracks) Effect of notches Creep testing (physical creep test, influence of stress and temperature, Larson Miller parameter) Wear testing Non destructive testing application for overhaul of jet engines
Literature	 E. Macherauch: Praktikum in Werkstoffkunde, Vieweg G. E. Dieter: Mechanical Metallurgy, McGraw-Hill R. Bürgel: Lehr- und Übungsbuch Festigkeitslehre, Vieweg R. Bürgel: Werkstoffe sicher beurteilen und richtig einsetzen, Vieweg

Course L0908: Turbo	Jet Engines
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
	Mündliche Prüfung
Examination duration and scale	45 min
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 L1820: System	n Simulation
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	 Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example: Heat transfer Example: System with different subsystems
Literature	 Modelica Association: "Modelica Language Specification - Version 3.3", Linköping, Sweden, 2012 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	n Simulation
Тур	Recitation Section (large)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



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



Course L0176: Reliabi	lity in Engineering Dynamics
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	
Examination duration and scale	90 min.
Lecturer	Prof. Uwe Weltin
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: Reliabi	lity 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	
Examination duration and scale	90 min
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course



Course L1554: Reliabi	lity of avionics assemblies
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed: Survey of the role of electronics in aviation System levels: From silicon to mechatronic systems Semiconductor components, assemblies, systems Challenges of electronics: Requirements for AVT Methods and techniques of AVT Error patterns for assemblies and avoidance of errors Reliability of Avionics COTS, ROTS, MOTS and the F³I concept Future challenges for electronics
	- Skript zur Vorlesung Hanke, HJ.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999



Course L1555: Reliabi	lity of avionics assemblies
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	
Examination duration and scale	90 Minuten
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed: Survey of the role of electronics in aviation System levels: From silicon to mechatronic systems Semiconductor components, assemblies, systems Challenges of electronics in electronics: Requirements for AVT Methods and techniques of AVT Error patterns for assemblies and avoidance of errors Reliability analysis for printed circuit boards (PCBs) Reliability of Avionics COTS, ROTS, MOTS and the F ³ I concept Future challenges for electronics
Literature	- Skript zur Vorlesung Hanke, HJ.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994 Scheel, W.: Baugruppentechnologie der Elektronik. Montage. Verlag Technik, 1999

Course L0749: Reliabi	lity of Aircraft Systems
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	
Examination duration and scale	90 Minuten
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

Nodule M0746: N					
Courses					
Fitle <i>I</i> icrosystem Engineering	(L0680)		Typ Lecture	Hrs/wk 2	CP 4
<i>l</i> icrosystem Engineering	(L0682)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper				
Admission Requirements	Nono				
Recommended Previous Knowledge	Racio courcos in physic	s, mathematics and e	electric engineering		
Educational Objectives	Atter taking nart success	sfully, students have	reached the following lea	arning resul	ts
Professional Competence					
-	1		nt technologies and mate	rials of MEI	MS as well
Skills	Students are able to and to evaluate the potentia		ne functional behaviour o	f MEMS cor	nponents a
Personal Competence					
	Students are able to so	olve specific problen	ns alone or in a group a	nd to prese	ent the resu
Competence Social Competence	Students are able to so accordingly.	quire particular know	ledge using specialized		
Competence Social Competence Autonomy	Students are able to so accordingly. Students are able to acc	quire particular know ledge with other field	rledge using specialized ds.		
Competence Social Competence Autonomy	Students are able to so accordingly. Students are able to acc and associate this know Independent Study Time	quire particular know ledge with other field	rledge using specialized ds.		
Competence Social Competence Autonomy Workload in Hours	Students are able to so accordingly. Students are able to acc and associate this know Independent Study Time 6 Compulsory Bonus	quire particular know ledge with other field	rledge using specialized ds.	literature ar	
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement	Students are able to so accordingly. Students are able to acc and associate this know Independent Study Time 6 Compulsory Bonus	quire particular know ledge with other field e 124, Study Time in Form	rledge using specialized ds. Lecture 56	literature ar	
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement	Students are able to so accordingly. Students are able to acc and associate this know Independent Study Time 6 Compulsory Bonus No 10 % Written exam	quire particular know ledge with other field a 124, Study Time in Form Presentation	vledge using specialized l ds. Lecture 56 Descriptic	literature ar	



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

Course L0680: Microsystem Engineering							
Тур	Lecture						
Hrs/wk	2						
СР	4						
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28						
	Prof. Manfred Kasper						
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						
Literature	Yield, test and reliability M. Kasper: Mikrosystementwurf, Springer (2000) M. Madou: Fundamentals of Microfabrication, CRC Press (1997)						

Course L0682: Micros	ourse 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	Prof. Manfred Kasper				
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				

Module M0921: Electronic Circuits for Medical Applications

Courses			
Title	Тур	Hrs/wk	СР
Electronic Circuits for Medical Applications (L0696)	Lecture	2	3
Electronic Circuits for Medical Applications (L1056)	Recitation Section (small)	1	2
Electronic Circuits for Medical Applications (L1408)	Practical Course	1	1

Module Responsible							
Admission Requirements							
Recommended Previous Knowledge	After taking part successfully, students have reached the following learning results						
Educational Objectives							
Professional Competence							
Knowledge	 Students can explain the basic functionality of the information transfer by the centr nervous system Students are able to explain the build-up of an action potential and its propagation along an axon Students can exemplify the communication between neurons and electronic devices Students can describe the special features of low-noise amplifiers for medic applications Students can explain the functions of prostheses, e. g. an artificial hand Students are able to discuss the potential and limitations of cochlea implants ar artificial eyes 						
Skills	 Students can calculate the time dependent voltage behavior of an action potential Students can give scenarios for further improvement of low-noise and low-pow signal acquisition. Students can develop the block diagrams of prosthetic systems Students can define the building blocks of electronic systems for an articifial eye. 						
Personal Competence							
Social Competence	 Students are trained to solve problems in the field of medical electronics in team together with experts with different professional background. Students are able to recognize their specific limitations, so that they can ask f assistance to the right time. Students can document their work in a clear manner and communicate their results a way that others can be involved whenever it is necessary 						
Autonomy	 Students are able to realistically judge the status of their knowledge and to define actions for improvements when necessary. Students can break down their work in appropriate work packages and schedule the work in a realistic way. Students can handle the complex data structures of bioelectrical experiments withon needing support. 						



		nts are able mental work		a responsib	le manne	r in all cases and situations of	
Workload in Hours	Independent	Study Time 1	124, Study 7	ime in Lectur	e 56		
Credit points	6						
	Compulsory	Bonus	Form		D	escription	
Course achievement	Yes	None	Subject practical w	theoretical vork	and		
	No	None	Excercises	3			
	Written exam						
Examination duration and scale	90 min						
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory						



Course L0696: Electro	nic Circuits 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 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



ourse L1408: Electro	nic Circuits 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 (L0670)	Lecture	2	3
Lattice-Boltzmann methods for the simulation of free surface flows (L2066)	Lecture	2	3
Modeling and Simulation of Maritime Systems (L2013)	Project-/problem-based Learning	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 and Theoretical Fluiddynamics (L0240)	Lecture	2	3
Technical Elements and Fluid Mechanics of Sailing Ships (L0873)	Lecture	2	3
Technology of Naval Surface Vessels (L0765)	Lecture	2	3

Module Responsible		
Admission Requirements	None	
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 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 supply 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 Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory	

Course L1896: Outfitti	ng and 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
	Mündliche Prüfung
Examination duration and scale	30 min
	Dr. Hendrik Vorhölter
Language	
Cycle	
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 - Heavy lift and offshore construction vessels - Dredgers and rock dumping vessels - Diving support vessels
Literature	Chakrabarti, S. (2005): Handbook of Offshore Engineering. Elsevier. Amsterdam, London Volker Patzold (2008): Der Nassabbau. Springer. Berlin Milwee, W. (1996): Modern Marine Salvage. Md Cornell Maritime Press. Centreville. DNVGL-ST-N001 "Marine Operations and Marin Warranty" IMCA M 103 "The Design and Operation of Dynamically Positioned Vessels" 2007-12 IMCA M 182 "The Safe Operation of Dynamically Positioned Offshore Supply Vessels" 2006- 03 IMCA M 187 "Lifting Operations" 2007-10 IMCA SEL 185 "Transfer of Personnel to and from Offshore Vessels" 2010-03



Course L0670: Design	of Underwater Vessels
21	Lecture
Hrs/wk	
СР	
Workload in Hours Examination Form	Independent Study Time 62, Study Time in Lecture 28
Examination duration	
and scale	30 min
	Peter Hauschildt
Language	
Cycle	
	The lectures will give an overview about the design of underwater vessels. The Topics are:
	1.) Special requirements on the design of modern, konventional submarines
	2.) Design history
	3.) Generals description of submarines
	4.) Civil submersibles
	5.) Diving, trim, stability
	6.) Rudders and Propulsion systems
	7.) Air Independent propulsion
	8.) Signatures
Content	9.) Hydrodynamics and CFD
	10.) Weapon- and combatmangementsystems
	11.) Safety and rescue
	12.) Fatigue and shock
	13.) Ships technical systems
	14.) Electricals Systems and automation
	15.) Logisics
	16.) Accomodation
	Some of the lectures will be Hheld in form of a excursion to ThyssenKrupp Marine Systems ir 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	
	Mündliche Prüfung	
Examination duration and scale	30 min	
Lecturer	Dr. Christian F. Janßen	
Language	DE/EN	
Cycle	WiSe	
Content	This lecture addresses Lattice Boltzmann Methods for the simulation of free surface flows. After an introduction to the basic concepts of kinetic methods (LGCAs, LBM,), recent LBM extensions for the simulation of free-surface flows are discussed. Parallel to the lecture, selected maritime free-surface flow problems are to be solved numerically.	
Literature	Krüger et al., "The Lattice Boltzmann Method - Principles and Practice", Springer Zhou, "Lattice Boltzmann Methods for Shallow Water Flows", Springer Janßen, "Kinetic approaches for the simulation of non-linear free surface flow problems in civil and environmental engineering", PhD thesis, TU Braunschweig, 2010.	

Course L2013: Modelin	ng 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
	Mündliche Prüfung
Examination duration and scale	30 min
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: Offsho	re 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 scale	45 min	
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 Ad	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			
Examination duration and scale	30 min		
Lecturer	Dr. Dietrich Wittekind		
Language	DE		
Cycle	SoSe		
Content			
Literature			

Course L0352: Ship Dy	Course L0352: Ship Dynamics	
Тур	Lecture	
Hrs/wk	2	
CP	3	

Examination Form		
Examination duration and scale	60 min	
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 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 un Schiffstheorie, Technische Universität Hamburg-Harburg, 2014 Abdel-Maksoud, M., Ship Dynamics, Lecture notes, Institute for Fluid Dynamic an Ship Theory, Hamburg University of Technology, 2014 Bertram, V., Practical Ship Design Hydrodynamics, Butterworth-Heinemann, Linaci House - Jordan Hill, Oxford, United 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 Universi Press, United Kingdom, 1990 Handbuch der Werften, Deutschland, 1986 Jensen, J. J., Load and Global Response of Ships, Elsevier Science, Oxford, Unite Kingdom, 2001 Lewis, Edward V. (ed.), Principles of Naval Architecture - Motion in Waves an Controllability, Society of Naval Architects and Marine Engineers, Jersey City, N 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, Unite Kingdom, 1998 	

Course L0240: Selecte	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	
	Mündliche Prüfung	
Examination duration and scale	30 min	
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 Elements and Fluid Mechanics of Sailing Ships	
Тур	Lecture
Hrs/wk	2
СР	3
	Independent Study Time 62, Study Time in Lecture 28
Examination Form	
Examination duration and scale	
	Prof. Thomas Rung, DiplIng. Peter Schenzle
Language	
Cycle	
	Principles of Sailing Mechanics:
	- Sailing: Propulsion from relative motion
	- Lifting foils: Sails, wings, rudders, fins, keels
	- Wind climate: global, seasonal, meteorological, local
	- Aerodynamics of sails and sailing rigs
	- Hydrodynamics of Hulls and fins
	Technical Elements of Sailing:
	- Traditional and modern sail types
Content	- Modern and unconventional wind propulsors
	- Hull forms and keel-rudder-configurations
	- Sailing performance Prediction (VPP)
	- Auxiliary wind propulsion (motor-sailing)
	Configuration of Sailing Ships:
	- Balancing hull and sailing rig
	- Sailing-boats and -yachts
	- Traditional Tall Sailing Ships
	- Modern Wind-Ships
Literature	 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 Naval Surface Vessels		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
	Mündliche Prüfung	
Examination duration and scale	30 min	
Lecturer	Dr. Martin SchötteIndreyer	
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) 	

Module M1161: T	urbomachinery				
Courses					
Title		Тур	Hrs/wk	СР	
Turbomachines (L1562) Turbomachines (L1563)		Lecture Recitation Section (large)	3	4 2	
		recitation Section (large)	1	2	
Module Responsible Admission					
Requirements	None				
Recommended Previous Knowledge	Technical Thermodynamics I, II, Fluid Dynamics	s, Heat Transfer			
Educational Objectives	After taking part successfully, students have rea	ached the following lea	rning result	S	
Professional					
Competence	The students can				
Knowledge	 distinguish the physical phenomena of conversion of energy, understand the different mathematic modelling of turbomachinery, calculate and evaluate turbomachinery. 				
	The students are able to				
Skills	- understand the physics of Turbomachinery,				
	- solve excersises self-consistent.				
Personal Competence					
	The students are able to				
Social Competence	 discuss in small groups and develop an 	approach.			
	The students are able to				
A t = = = = = = = = = = = = = = = = = = =	 develop a complex problem self-consist 	tent,			
Autonomy	• analyse the results in a critical way,	1			
	 have an qualified exchange with other s 	students.			
Workload in Hours	Independent Study Time 124, Study Time in Le	cture 56			
Credit points					
Course achievement					
Examination					
Examination duration and scale					
Assignment for the Following Curricula	Product Development, Materials and Pro	as: Elective Compulsory uction: Specialisation duction: Specialisation	y Product E n Producti	on: Electiv	
	Compulsory Theoretical Mechanical Engineering: Technical Theoretical Mechanical Engineering: Specialise				

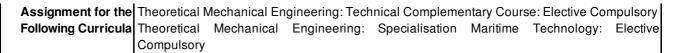
Course L1562: Turbomachines		
Тур	Lecture	
Hrs/wk	3	
СР	4	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Dr. Karsten Meier	
Language	DE	
Cycle	SoSe	
Content	 Topics to be covered will include: Application cases of turbomachinery Fundamentals of thermodynamics and 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 	

ourse L1563: Turbomachines	
Recitation Section (large)	
1	
2	
Independent Study Time 46, Study Time in Lecture 14	
Prof. Dr. Karsten Meier	
DE	
SoSe	
See interlocking course	
See interlocking course	

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Module M1177: Maritime Technology and Maritime Systems

Title		Тур	Hrs/wk	СР	
Analysis of Maritime Systems (L0068)		Lecture	2	2	
Analysis of Maritime Systems (L0069)		Recitation Section (small)		1	
Introduction to Maritime Te		Lecture	2	2	
Introduction to Maritime Te		Recitation Section (small)	1	1	
Module Responsible	Prof. Moustafa Abdel-Maksoud				
Admission Requirements	None				
	Solid knowledge and competences in mechanics, fluid dynamics and analysis (series periodic functions, continuity, differentiability, integration, multiple variables, ordinaray an partial differential equations, boundary value problems, initial conditions and eigenvalu problems).				
Educational Objectives	After taking part successfully, students have re	eached the following lea	rning resul	ts	
Professional					
Competence					
	After successful completion of this class, stude and methods in ocean engineering and t presented.			•	
	In detail, the students should be able to				
Knowledge	 describe the different aspects and topics in Maritime Technology, apply existing methods to problems in Maritime Technology, discuss limitations in present day approaches and perspectives in the future, Techniques for the analysis of offshore systems, Modeling and evaluation of dynamic systems, System-oriented thinking, decomposition of complex systems. 				
Skills	The students learn the ability of apply and transfer existing methods and techniques on nov questions in maritime technologies. Furthermore, limits of the existing knowledge and futu developments will be discussed.				
Personal					
Competence					
Social Competence	The processing of an exercise in a group of up to four students shall strengthen communication and team-working skills and thus promote an important working technicqu subsequent working days. The collaboration has to be illustrated in a community presenta of the results.		technicque		
	The course contents are absorbed in an exer a final exam in which a self-reflection of the lea			lly checked	
Workload in Hours	Independent Study Time 96, Study Time in Le	cture 84			
Credit points	6				
Course achievement	None				
Examination	Written exam				



Course L0068: Analysis of Maritime Systems		
Тур	Typ Lecture	
Hrs/wk	2	
СР	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: Analys	Course L0069: Analysis of Maritime Systems	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	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	



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. Sven Hoog	
Language	DE	
Cycle	WiSe	
Content	 Introduction Ocean Engineering and Marine Research The potentials of the seas Industries and occupational structures Coastal and offshore Environmental Conditions Physical and chemical properties of sea water and sea ice Flows, waves, wind, ice Biosphere Response behavior of Technical Structures 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: Introdu	Course L1614: Introduction to Maritime Technology	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Sven Hoog	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	



Module M1268: L	inear and Nonlinear Waves.			
Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear Wav	res (L1737)	Project-/problem-based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	Good Knowledge in Mathematics, Mec	hanics and Dynamics.		
Educational Objectives	After taking part successfully students	have reached the following lea	arning resu	Its
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 nove methods and procedures.			
Personal Competence				
-	Students can reach working results also in	groups.		
Autonomy	Students are able to approach given res		dentify and	follow up nove
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	INAVALAIONIECTURE AND UCEAN ENGINEERING. CORE QUAINICATION. ELECTIVE COMPLUSORY			

Course L1737: Linear	ourse 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		
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 M1183: L	aser systems and metho	ds of manufacturing	design and	analysis
Courses				
Title Laser Systems and Proce Methods for Analysing Pro	ess Technologies (L1612) oduction Processes (L0876)	Typ Lecture Lecture	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. Wolfgang Hintze			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stude	ents have reached the follov	ving learning resu	lts
Professional Competence				
Knowledge Skills				
Personal Competence				
Social Competence Autonomy				
Workload in Hours	Independent Study Time 124, Stud	ly Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Product Development, Materials Elective Compulsory Product Development, Materials a Product Development, Material Compulsory Theoretical Mechanical Engineer Elective Compulsory Theoretical Mechanical Engineering	nd Production: Specialisatio s and Production: Spe ing: Specialisation Product	on Production: Con cialisation Mater t Development ar	npulsory ials: Electiv nd Productior

Course L1612: Laser Systems and Process Technologies		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Claus Emmelmann	
Language	EN	
Cycle	WiSe	
Content	 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 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)	

Title		Тур	Hrs/wk	СР
Flexible Multibody Systems Optimization of dynamical		Lecture Lecture	2 2	3 3
Module Responsible				_
Admission Requirements				
Recommended Previous Knowledge	 Mathematics I, II, III Mechanics I, II, III, IV Simulation of dynamical Sy 	rstems		
Educational Objectives	After taking part successfully, stude	ents have reached the follow	ving learning resu	lts
Professional Competence				
Knowledae	Students demonstrate basic knowledge and understanding of modeling, simulation an analysis of complex rigid and flexible multibody systems and methods for optimizing dynam systems after successful completion of the module.			
	Students are able			
	+ to think holistically			
	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody systems			
	+ to describe dynamics problems mathematically			
	+ to optimize dynamics problems			
Personal Competence				
	Students are able to			
Social Competence	+ solve problems in heterogeneou	s groups and to document th	ne corresponding	results.
	Students are able to			
	+ assess their knowledge by means of exercises.			
Autonomy	+ acquaint themselves with the ne	cessary knowledge to solve	research oriented	d tasks.
Workload in Hours	Independent Study Time 124, Stud	ly Time in Lecture 56		
Credit points		,		
Course achievement				
Examination	Oral exam			
Examination duration and scale	30 min			

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

Course L1632: Flexible Multibody Systems		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Robert Seifried	
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: Optimiz	zation 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, Dr. Leo Dostal
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.



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Courses				
Title Biomaterials (L0593)		Typ Lecture	Hrs/wk 2	СР 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic and	surgical techniques is rec	ommended.	
Educational Objectives	After taking part successfully, studer	its have reached the follo	wing learning resu	lts
Professional Competence				
Knowledge	The students can describe the mate medical engineering, and their fields		and the materials	being used
Skills	The students can explain the advan	tages and disadvantages	of different kinds o	f biomateria
Personal Competence				
Social Competence	The students are able to discuss is replacements with student mates an		being present or b	being used
Autonomy	The students are able to acquire info with respect to its credibility.	ormation on their own. The	ey can also judge t	he informati
Workload in Hours	Independent Study Time 62, Study 7	ime in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	TRIOMODICAL ENDINGORING, SUBCIAIISATION MEDICAL TECHNOLOGY AND L'ONTROL THEORY, ELECT			

Course L0593: Biomaterials	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28

Lecturer Language	Prof. Michael Morlock EN
Cycle	WiSe
	Topics to be covered include:
	1. Introduction (Importance, nomenclature, relations)
	2. Biological materials
	2.1 Basics (components, testing methods)
	2.2 Bone (composition, development, properties, influencing factors)
	2.3 Cartilage (composition, development, structure, properties, influencing factors)
	2.4 Fluids (blood, synovial fluid)
	3 Biological structures
	3.1 Menisci of the knee joint
	3.2 Intervertebral discs
	3.3 Teeth
	3.4 Ligaments
	3.5 Tendons
Content	3.6 Skin
	3.7 Nervs
	3.8 Muscles
	4. Replacement materials
	4.1 Basics (history, requirements, norms)
	4.2 Steel (alloys, properties, reaction of the body)
	4.3 Titan (alloys, properties, reaction of the body)
	4.4 Ceramics and glas (properties, reaction of the body)
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)
	4.6 Natural replacement materials
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which are used for replacements in-vivo). Acquisition of basics for theses work in the area of biomechanics.
	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.
	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University September 1978. New York: Wiley, 1998.
Literature	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone 1988.
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.
	[602]

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

Hamburg	University of	Technology

Module M1173: A	pplied Statistics				
Courses					
Title Applied Statistics (L1584) Applied Statistics (L1586)			Typ Lecture Project-/problem-based Learning	Hrs/wk 2 2	CP 3 2
Applied Statistics (L1585)			Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge of stati	stical methods			
Educational Objectives	After taking part success	fully, students have re	ached the following lea	rning resu	lts
Professional Competence					
Knowledge	Students can explain the statistical methods and the conditions of their use.				
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results				
Personal Competence					
Social Competence	Team Work, joined prese	entation of results			
Autonomy	To understand and inter	pret the question and s	solve		
	Independent Study Time	e 110, Study Time in Le	ecture 70		
Credit points	6				
Course achievement	Compulsory BonusYesNone	Form Written elaboration	Descriptio	on	
Examination	Written exam				
Examination duration and scale	90 minutes, 28 questions	S			
-	Mechanical Engineering Mechatronics: Specialisa Mechatronics: Specialisa Biomedical Engineering Product Development, M Theoretical Mechanical Theoretical Mechanical Compulsory	ation System Design: I ation Intelligent System : Core qualification: Co laterials and Productic Engineering: Technica	Elective Compulsory ns and Robotics: Electiv ompulsory on: Core qualification: E al Complementary Cour	ve Compuls lective Cor	sory mpulsory e Compulsory



Course L1584: Applied	Statistics
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/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 Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum
	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	d Statistics
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
Content	The students receive a problem task, which they have to solve in small groups (n=5). They do have to collect their own data and work with them. The results have to be presented in an executive summary at the end of the course.
Literature	Selbst zu finden

Course L1585: Applied	Statistics
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
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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Module M1198: N	laterials Physics and Atomis	stic Materials Mode	eling	
Courses				
Title		Тур	Hrs/wk	СР
Atomistic Materials Model	ing (L1672)	Lecture	2	2
Materials Physics (L1624		Lecture	2	2
	ysics and Modeling (L2002)	Recitation Section	(small) 2	2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Advanced mathematics, physics and c	hemistry for students in e	ngineering or na	tural science
Educational Objectives	After taking part successfully, students	have reached the followi	ng learning resu	lts
Professional Competence				
	The students are able to			
	- explain the fundamentals of condens	ed matter physics		
	 describe the fundamentals of the microscopic structure and mechanics, thermodynamics and optics of materials systems. 			
Knowledge	- to understand concept and realization to estimate their potential and limitation		n atomistic mode	ling as well a
Skills	 After attending this lecture the students can perform calculations regares optical properties of condensed are able to transfer their known materials design problems. can select appropriate model care able to further develop simples. 	arding the thermodynami d matter systems ledge to related technolo descriptions for specific m	ogical and scient	tific fields, e.ç
Personal Competence		ons to specialists and to o	develop ideas fui	ther.
Social Competence	Students are able to assess their k practice.			
Autonomy	The students are able to assess the independently.	eir own strengths and v	veaknesses and	l define task
Workload in Hours	Independent Study Time 96, Study Tim	ne in Lecture 84		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	90 min			

Course L1672: Atomis	tic Materials Modeling
Тур	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 L1624: Materia	als Physics
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 L2002: Exercis	ses in Materials 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
Litoraturo	- Rudolf Gross und Achim Marx: Festkörperphysik
	- Neil Ashcroft and David Mermin: Solid State Physics



Module M1199: A	dvanced Functional Mate	rials		
Courses				
Title Advanced Functional Mat	erials (L1625)	Typ Seminar	Hrs/wk 2	CP 6
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in Materials Scier	nce, e.g. Materials Science I	/11	
Educational Objectives	After taking part successfully, stude	nts have reached the follow	ing learning resu	Its
Professional Competence				
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particular metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.			
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications.			
Personal Competence				
Social Competence	The students are able to present so	lutions to specialists and to	develop ideas fui	rther.
Autonomy	 The students are able to assess their own strengths a gather new necessary expension 			
Workload in Hours	Independent Study Time 152, Study	y Time in Lecture 28		
Credit points	6			
Course achievement	None			
	Presentation			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Materials Science: Core qualification: Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory			

Course L1625: Advance	ced Functional Materials
Тур	Seminar
Hrs/wk	2
СР	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	 Porous Solids - Preparation, Characterization and Functionalities Fluidics with nanoporous membranes Thermoplastic elastomers Optimization of polymer properties by nanoparticles Fiber composites in automotive Modeling of materials based on quantum mechanics Biomaterials
Literature	Wird in der Veranstaltung bekannt gegeben

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(L1558)			
Computer and communication technology in cabin electronics and avionics (L1557) Lecture Computer and communication technology in cabin electronics and avionics (L1558) Recitation Project- Learning Model-Based Systems Engineering (MBSE) with SysML/UML (L1551) Project- Learning Module Responsible Requirements Prof. Ralf God Admission Requirements None Basic knowledge in: • Mathematics • Thermodynamics • Electrical Engineering • Control Systems • Thermodynamics • Systems Engineering Previous Knowledge • Control Systems Previous knowledge in: • Systems Engineering Educational Objectives After taking part successfully, students have reached t • describe the structure and operation of computer arc • explain the structure and operation of digital communication • explain architectures of cabin electronics, integrat Data Communication Network (ADCN) • understand, operate and maintain a Minicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management skills Skiller • Students are able to: • understand, operate and maintain a dinicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputer Personal Competence Students are able to: • elaborate partial results and merge with others to for Students are able to:			
L1557) Letture Computer and communication technology in cabin electronics and avionics Recitatie Model-Based Systems Engineering (MBSE) with SysML/UML (L1551) Project-Learning Module Responsible Prof. Ralf God Admission Requirements None Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Previous knowledge in: • Systems Engineering Previous Knowledge Control Systems Previous knowledge in: • Systems Engineering • Students are able to: • describe the structure and operation of computer arc • explain the structure and operation of digital commu • explain architectures of cabin electronics, integrat Data Communication Network (ADCN) • understand the approach of Model-Based Systems hardware and software-based cabin systems Students are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputer Personal Competence Students are able to: • elaborate partial results and merge with others to for Students are able to:		Hrs/wk	СР
Computer and communication technology in cabin electronics and avionics (L1558) Recitation (L1558) Model-Based Systems Engineering (MBSE) with SysML/UML (L1551) Project- Learning Module Responsible Prof. Ralf God Admission Requirements None Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Free Previous Knowledge • Thermodynamics • Electrical Engineering • Control Systems Free Previous Knowledge After taking part successfully, students have reached to • describe the structure and operation of computer arc • explain the structure and operation of computer arc • explain the structure and operation of digital communication • explain architectures of cabin electronics, integrat Data Communication Network (ADCN) • understand the approach of Model-Based Systems hardware and software-based cabin systems Students are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputer Personal Competence Students are able to: • elaborate partial results and merge with others to for Students are able to:	9	2	2
Model-Based Systems Engineering (MBSE) with SysMUDWL (L1SS1) Learning Module Responsible Prof. Ralf God Admission Requirements None Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Mathematics • Mechanics • Thermodynamics • Electrical Engineering Previous Knowledge Previous Knowledge Previous knowledge in: • Systems Engineering Educational Objectives After taking part successfully, students have reached to • describe the structure and operation of computer arc • explain the structure and operation of digital commun • explain architectures of cabin electronics, integrat Data Communication Network (ADCN) • understand the approach of Model-Based Systems hardware and software-based cabin systems Students are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputer Personal Competence Students are able to: • elaborate partial results and merge with others to for	ion Section (small)	1	1
Admission Requirements None Basic knowledge in: • Mathematics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Previous Knowledge Previous Knowledge Previous knowledge in: • Systems Engineering Educational Objectives After taking part successfully, students have reached to • explain architecture and operation of computer arc • explain architectures of cabin electronics, integrat Data Communication Network (ADCN) • understand the approach of Model-Based Systems hardware and software-based cabin systems Students are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputer Personal Competence Students are able to: • elaborate partial results and merge with others to for	-/problem-based Ig	3	3
Requirements None Basic knowledge in: • Mathematics • Mechanics • Electrical Engineering • Control Systems Previous Knowledge Previous knowledge in: • Systems Engineering Educational Objectives After taking part successfully, students have reached to • Systems Engineering Educational Objectives Students are able to: • describe the structure and operation of computer arc • explain the structure and operation of digital commune • explain architectures of cabin electronics, integrat Data Communication Network (ADCN) • understand the approach of Model-Based Systems hardware and software-based cabin systems Students are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputer Personal Competence Students are able to: • elaborate partial results and merge with others to for			
Recommended • Mathematics Previous Knowledge • Electrical Engineering Control Systems Previous knowledge in: • Systems Engineering • Systems Engineering Educational Objectives After taking part successfully, students have reached t Professional Competence Students are able to: • describe the structure and operation of computer arc • explain the structure and operation of digital communic • explain architectures of cabin electronics, integrat Data Communication Network (ADCN) • understand the approach of Model-Based Systems hardware and software-based cabin systems Students are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputer • elaborate partial results and merge with others to for Students are able to: • elaborate partial results and merge with others to for			
Objectives After taking part successfully, students have reached to the structure and operation of computer area operation of computer area operation of digital communities of explain the structure and operation of digital communities of explain architectures of cabin electronics, integrate Data Communication Network (ADCN) <i>Knowledge</i> • explain architectures of cabin electronics, integrate Data Communication Network (ADCN) • understand the approach of Model-Based Systems hardware and software-based cabin systems Students are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate or connect a minicomputer with a cabin management over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputer Personal Competence Students are able to: Students are able to: • elaborate partial results and merge with others to for			
CompetenceStudents are able to: • describe the structure and operation of computer arc • explain the structure and operation of digital communic • explain architectures of cabin electronics, integrat Data Communication Network (ADCN) • understand the approach of Model-Based System: hardware and software-based cabin systemsStudents are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputerPersonal CompetenceStudents are able to: • elaborate partial results and merge with others to for Students are able to:	the following lea	rning resu	lts
 • describe the structure and operation of computer arco explain the structure and operation of digital communication is explain architectures of cabin electronics, integrat Data Communication Network (ADCN) • understand the approach of Model-Based Systems hardware and software-based cabin systems Students are able to: • understand, operate and maintain a Minicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputer Students are able to: • elaborate partial results and merge with others to for Students are able to: 			
 • understand, operate and maintain a Minicomputer • build up a network communication and communicate • connect a minicomputer with a cabin management • over a AFDX®-Network • model system functions by means of formal langua code from the models • execute software code on a minicomputer Personal Competence Students are able to: • elaborate partial results and merge with others to for Students are able to:	nication Network ted modular avi	onics (IMA	
Competence Students are able to: Social Competence • elaborate partial results and merge with others to for Students are able to:	t system (A380 (CIDS) and	communica
Students are able to: • elaborate partial results and merge with others to for Students are able to:			
	rm a complete so	lution	
Workload in Hours Independent Study Time 96, Study Time in Lecture 84	4		
Credit points 6			
Course achievement None			

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

Course L1557: Computer and communication technology in cabin electronics and avionics		
Тур	Lecture	
Hrs/wk	2	
СР	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 • Compation • Compation • Compation • Compation • Compation • Compation • Computer • Computer • Compation • Compatin • Compation • Compation • Compatin • Compation • C	
Literature	 Skript zur Vorlesung Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003 Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004 Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006 	

Course L1558: Compu	Iter and communication technology in cabin electronics and avionics		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Ralf God		
Language	DE		
Cycle	WiSe		
Content	The objective of the lecture with the corresponding exercise is the acquisition of knowledge of computer and communication technology in electronic systems in the cabin and in aircraft. For the system engineer the strong interaction of software, mechanical and electronic system components nowadays requires a basic understanding of cabin electronics and avionics. The course teaches the basics of design and functionality of computers and data networks. Subsequently it focuses on current principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronics and cabin networks: • History of computer and network technology • 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 		

Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML		
Тур	Project-/problem-based Learning	
Hrs/wk	3	
СР	3	
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal languages SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Based Systems Engineering (MBSE) on a realistic hardware platform (e.g. Arduino®, Raspberry Pi®): • What is a model? • What is Systems Engineering? • Survey of MBSE methodologies • The modelling languages SysML /UML • Tools for MBSE • Best practices for MBSE • Requirements specification, functional architecture, specification of a solution • From model to software code • Validation and verification: XiL methods • Accompanying MBSE project	
Literature	 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	M1342:	Polymers
modalo		

Courses					
Title Structure and Properties of Polymers (L0389)		Тур	Hrs/wk	СР	
Processing and design wi		Lecture Lecture	2 2	3 3	
Module Responsible				-	
Admission Requirements	None				
Recommended Previous Knowledge	Basics: chemistry / physics / material science				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
•	Students can use the knowledge of	of plastics and define the nec	essary testing an	d analysis.	
	They can explain the complex rela	ationships structure-property	relationship and		
Knowledge	the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).				
	Students are capable of				
Skills	- using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.				
	- selecting appropriate solution stiffness, corrosion resistance.	s for mechanical recycling	problems and s	zing exampl	
Personal Competence					
	Students can				
	- arrive at funded work results in h	eterogenius groups and doc	ument them.		
Social Competence	- provide appropriate feedback an	d handle feedback on their c	own performance	constructively	
	Students are able to				
	- assess their own strengths and weaknesses.				
Autonomy	- assess their own state of learning in specific terms and to define further work steps on this basis.				
	- assess possible consequences of	of their professional activity.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Course achievement					
	Written exam				
Examination duration and scale	180 min				
	Materials Science: Specialisation Biomedical Engineering: Specialis			sory	

	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory			
Assignment for the	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective			
	Product Development, Materials and Production: Specialisation Production: Elective Compulsory			
	Product Development, Materials and Production: Specialisation Materials: Elective Compulsory			
	Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory			
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory			

Course L0389: Structure and Properties of Polymers				
Тур	Lecture			
Hrs/wk				
СР				
Workload in Hours	ndependent 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 			
Litoratura				
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag			

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

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Courses				
Title		Тур	Hrs/wk	СР
	n of Software Systems (L1657)	Lecture	2	3
Design and Implementation of Software Systems (L1658) Practical Course 2 3			3	
	Prof. Bernd-Christian Renner			
Admission Requirements	None			
	- Imperativ programming languages	(C, Pascal, Fortran or similar)		
	Recommended Previous Knowledge and function calls			
Educational Objectives	Atter taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	Students are able to describe mechatronic systems and define requirements.			
Skills	Students are able to design and implement mechatronic systems. They are able to argue th combination of Hard- and Software and the interfaces.			
Personal Competence				
Social Competence	Students are able to work goal-oriented in small mixed groups, learning and broadenin teamwork abilities and define task within the team.			
Autonomy	Students are able to solve individually exercises related to this lecture with instructiona direction. Students are able to plan, execute and summarize a mechatronic experiment.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	190 min			
-	Mechatronics: Core qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsor			

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

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



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

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

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Module M1249: N	Iumerical Methods for Me	edical Imaging		
Courses				
Title Numerical Methods for Me Numerical Methods for Me		Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. Tobias Knopp			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stud	ents have reached the following lea	rning resul	IS
Professional Competence				
Knowledge Skills				
Personal Competence				
Social Competence Autonomy				
Workload in Hours	Independent Study Time 124, Stu	dy Time in Lecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	90 min			
	Electrical Engineering: Specialisa Electrical Engineering: Specialisa Computational Science and Engi Elective Compulsory Theoretical Mechanical Engineer Compulsory	Intelligence Engineering: Elective (tion Medical Technology: Elective (tion Modeling and Simulation: Elect neering: Specialisation Systems Er ring: Specialisation Bio- and Medic ng: Technical Complementary Cour	compulsory ive Compu- ngineering a cal Techno	sory and Robotics logy: Elective

Course L1694: Numerical Methods for Medical Imaging		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Tobias Knopp	
Language	DE	
Cycle	WiSe	
Content		
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 	

Course L1695: Numerical Methods for 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
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Module M1336: S	Soft Computing - Introduction to Machine Learni	ng	
Courses			
Title Soft Computing (L1869)	Typ Lecture	Hrs/wk 4	CP 6
Module Responsible	Prof. Karl-Heinz Zimmermann		
Admission Requirements	None		
	Bachelor in Computer Science.		
Recommended Previous Knowledge	I Basics in higher mathematics are inevitable, like calculus, linear algebra, graph theory at		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	Students are able to formalize, compute, and analyze belief networks, alignments sequences, hidden Markov models, phylogenetic tree models, neural networks, and fuzz controllers. In particular, inference and learning in belief networks are important topics that the students should be able to master.		rks, and fuzz
Skills	Students can apply the relevant algorithms and determine the make use of the statistics language R.	ir complexity,	and they car
Personal			
Competence Social Competence	Students are able to solve specific problems alone or in a grou	p and to prese	ent the result
Autonomy	Students are able to acquire new knowledge from newer liter acquired knowledge to other fields.	rature and to	associate the
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	s 6		
Course achievement	t None		
Examination	Oral exam		
Examination duration and scale	125 min		
	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science Elective Compulsory		

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

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Module M1294: Bioenergy

Courses

Title		Тур	Hrs/wk	СР
Biofuels Process Technology (L0061)		Lecture	1	1
Biofuels Process Technology (L0062)		Recitation Section (small)	1	1
World Market for Commodities from Agriculture and Forestry (L1769)		Lecture	1	1
Thermal Utilization of Biomass (L1767)		Lecture	2	2
Thermal Utilization of Bion	nass (L1768)	Recitation Section (small)	1	1
-	Prof. Martin Kaltschmitt			
Admission Requirements	None			
Recommended Previous Knowledge	none			
Educational Objectives	After taking part successfully, students hav	e reached the following lea	rning resu	lts
Professional Competence				
Competence	Studente ero oble te reproduce en in i	lanth outling of another	roduction f	rom blome-
Knowledge	Students are able to reproduce an in-c aerobic and anaerobic waste treatment p produced emissions.	rocesses, the gained produ	icts and th	e treatment
Skills	Students can apply the learned theoretica explain relationships for different tasks, like In this context, students are also able to so and biogas, biodiesel and bioethanol use.	e dimesioning and design o lve computational tasks for	f biomass	power plants
Personal				
Competence				
Social Competence	Students can participate in discussions to a as an energy source.	design and evaluate energy	/ systems (using bioma
Autonomy	Students can independently exploit sources with respect to the emphasis of the lectures. The can choose and aquire the for the particular task useful knowledge. Furthermore, they can solve computational tasks of biomass-based energy systems independently with the assistance of the lecture. Regarding to this they can assess their specific learning level ar can consequently define the further workflow.			
Workload in Hours	Independent Study Time 96, Study Time in	Lecture 84		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	3 hours written exam			
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation Compulsory Energy and Environmental Engineeri Engineering: Elective Compulsory Energy Systems: Specialisation Energy Sy International Management and Engineer Compulsory Renewable Energies: Core qualification: C Theoretical Mechanical Engineering: Tech Process Engineering: Specialisation	ng: Specialisation Energ rstems: Elective Compulsory ing: Specialisation II. Rene Compulsory unical Complementary Cour	y and l v ewable En se:Electiv	Environment ergy: Electiv e Compulsor

Compulsory

	Is Process Technology
Тур	Lecture
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. 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
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 Verfahre Mousdale; Biofuels - Biotechnology, Chemistry and Sustainable Development VDI Wärmeatlas



Course L0062: Biofuel	Course L0062: Biofuels Process Technology	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Oliver Lüdtke	
Language	DE	
Cycle	WiSe	
Content	 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 N	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
	 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 15 years there have also been rapidly rising global requirements of oils & fats for non-food

Content	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

Тур	Lecture
Hrs/wk	
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	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 environmental basics of all options to provide energy from bioma from a German and international point of view. Additionally different system approaches to u biomass for energy, aspects to integrate bioenergy within the energy system, technical a economic development potentials, and the current and expected future use within the energy system are presented. The course is structured as follows: Biomass as an energy carrier within the energy system; use of biomass in Germa and world-wide, overview on the content of the course Photosynthesis, composition of organic matter, plant production, energy cropt residues, organic waste Biomass provision chains for woody and herbaceous biomass, harvesting at provision, transport, storage, drying Thermo-chemical conversion of solid biofuels Basics of thermo-chemical conversion D ir e ct thermo-chemical conversion D ir e ct thermo-chemical conversion Gasification: Gasification technologies, producer gas cleaning technologies options to use the cleaned producer gas for the provision of heat, electric and/or fuels Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for t provision of charcoal, oil cleaning technologies, options to use the pyrolysis and charcoal as an energy carrier as well as a raw material Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil see and oil fruits, vegetable oil production, production of a biofuel with standardiz characteristics (trans-esterification, hydrogenation, co-processing in existii refineries), options to use the is fuel, options to use the residues (i.e. meal, glycerine) Bio-chemical conversion of biomass Basics of bio-chemical conversion Edusition of biomass Basics of bio-chemical conversion Edusition of biomass

Course L1768: Thermal Utilization of Biomass		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Martin Kaltschmitt	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1232: A	Arctic Technology			
Courses				
Title Typ Hrs/wk				СР
Ice Engineering (L1607)		Lecture	2	2
Ice Engineering (L1615)		Recitation Section (small)	1	2
Ship structural design for	arctic conditions (L1575)	Project-/problem-based Learning	2	2
Module Responsible	Prof. Sören Ehlers			
Admission Requirements	None			
Recommended Previous Knowledge	none			
Educational Objectives	After taking part successfully, students have reached the following 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. Calculation models to assess ice loads can be used and a structure can be designed accordingly.			
Personal Competence				
Social Competence	Students are capable to present their structural design and discuss their decisions constructively in a group.			
Autonomy	Independent and individual assignment tasks can be carried out and presented whereby the capabilities to both, present and defend, the skills and findings will be achieved.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination				
Examination duration and scale	30 min			
Assignment for the Following Curricula	Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Ship and Offshore Technology: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory			

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Course L1607: Ice Eng	ineering
	Lecture
Hrs/wk	
CP	
	 Independent Study Time 32, Study Time in Lecture 28
	Dr. Walter Kuehnlein
Language	
Cycle	
Content	 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 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 Computational Modelling of Ice-Structure Interaction Processes Alternative numerical crack propagation modelling methods. Examples or cohesive element models for real life structures. Discussion of contribution of ice properties, hydrodynamics and rubble. Ice Design Philosophies and Perspectives 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 tailure 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 sh
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 structural design for arctic conditions		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Sören Ehlers, Dr. Rüdiger Ulrich Franz von Bock und Polach	
Language	DE/EN	
Cycle	WiSe	
Content	The structural design under ice loads will be carried out for an individual case	
Literature	FSICR, IACS PC and assorted publications	

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Courses					
Courses					
Title	and Offeners Structures (11501)	Тур	Hrs/wk CP		
	and Offshore Structures (L1521) and Offshore Structures (L1522)	Lecture Recitation Section	2 3 (small) 2 3		
	•				
Module Responsible					
Admission Requirements	None				
Recommended Previous Knowledge	I maahaniga and maahaniga of materiala				
Educational Objectives	After taking part successfully students I	nave reached the followi	ing learning results		
Professional					
Competence					
	Students are able to				
Knowledge	 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 lift prediction based on the crack propagation.				
Personal					
Competence					
Social Competence	The students are able to communicate shipbuilding and component supply inc		rofessional environment in		
Autonomy	The widespread scope of gained know future profession independently and co	-	ents to handle situations in th		
Workload in Hours	Independent Study Time 124, Study Tir	ne in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following Curricula					

Course L1521: Fatigue	Strength of Ships and Offshore Structures
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 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
Literature	 Siehe Vorlesungsskript

Course 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	

Module M1235: E	lectrical Power Systems I: Introdu	uction to Electrica	al Power	Systems
Courses				
	I: Introduction to Electrical Power Systems (L1670) I: Introduction to Electrical Power Systems (L1671)		Hrs/wk 3 2	CP 4 2
Module Responsible	Prof. Christian Becker			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Electrical Engineering			
Educational Objectives	After taking part successfully, students have re	eached the following lea	Irning resul	ts
Professional Competence				
Knowledge	Students are able to give an overview of conventional and modern electric power systems. They can explain in detail and critically evaluate technologies of electric power generation, transmission, storage, and distribution as well as integration of equipment into electric power systems.			
Skills	With completion of this module the students are able to apply the acquired skills in applications of the design, integration, development of electric power systems and to assess the results.			
Personal				
Competence				
Social Competence	The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in 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 L	ecture 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 - 150 minutes			
Assignment for the Following Curricula	Endingering, Flective Complificati			

Course L1670: Electric	cal Power Systems I: Introduction to Electrical Power Systems		
Тур	Lecture		
Hrs/wk	3		
СР	4		
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	Prof. Christian Becker		
Language)E		
Cycle	WiSe		
Content	 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 		

Course L1671: Electric	cal Power Systems I: Introduction to Electrical Power Systems
Тур	Recitation Section (large)
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe
Content	 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 (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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Module M1213: A	vionics for	safety-critic	al Systems	5		
Courses						
Title Avionics of Safty Critical S Avionics of Safty Critical S	Systems (L1641)			Typ Lecture Recitation Section (smal	,	CP 3 1
Avionics of Safty Critical S				Practical Course	1	2
Module Responsible		е				
Admission Requirements	None					
Recommended Previous Knowledge		natics al Engineering				
Educational Objectives	After taking pa	rt successfully, st	udents have re	ached the following le	arning resu	lts
Professional Competence						
Knowledge	 describe the most important principles and components of safety-critical avionics denote processes and standards of safety-critical software development depict the principles of Integrated Modular Avionics (IMA) can compare hardware and bus systems used in avionics assess the difficulties of developing a safety-critical avionics system correctly 					
Skills	programplan av	 e real-time hardw m A653 applicatio vionics architectur test scripts and as	ons res up to a certa	ain extend		
Personal Competence	Students can:					
Social Competence	jointly oexchar	develop solutions age information fo t development re	ormally with othe	er teams		
Autonomy	 Students can: understand the requirements for an avionics system autonomously derive concepts for systems based on safety-critical avionics 					
Workload in Hours	Independent S	Study Time 124, S	Study Time in Le	ecture 56		

Credit points	6				
	Compulsory	Bonus	Form		Description
Course achievement	Yes	None	Subject practical w	theoretical ork	and
Examination					
Examination duration and scale	30 min				
•	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory				

Course L1640: Avionic	es of Safty Critical Systems			
Тур	Lecture			
Hrs/wk	2			
СР	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	or. Martin Halle			
Language)E			
Cycle	WiSe			
Content	Avionics are all kinds off flight electronics. Today there is no aircraft system function without avionics, and avionics are one main source of innovation in aerospace industry. Since many system functions are highly safety critical, the development of avionics hardware and software underlies mandatory constraints, technics, and processes. It is inevitable for system developers and computer engineers in aerospace industry to understand and master these. This lecture teaches the risks and techniques of developing safety critical hardware and software; major avionics components; integration; and test with a practical orientation. A focus is on Integrated Modular Avionics (IMA). The lecture is accompanied by a mandatory and laboratory exercises. Content: 1. Introduction and Fundamentals 2. History and Flight Control 3. Concepts and Redundancy 4. Digital Computers 5. Interfaces and Signals 6. Busses 7. Networks 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: Avionic	Course L1641: Avionics of Safty Critical Systems		
Тур	Typ Recitation Section (small)		
Hrs/wk	1		
СР	1		
Workload in Hours	dependent Study Time 16, Study Time in Lecture 14		
Lecturer	Dr. Martin Halle		
Language	DE		
Cycle	le WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1652: Avionic	ourse L1652: Avionics of Safty Critical Systems		
Тур	Typ Practical Course		
Hrs/wk	1		
СР	2		
Workload in Hours	dependent 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 M1178: M	lanoeuvrability and Shal	low Water Ship Hydro	odynamics	
Courses				
Title		Тур	Hrs/wk	СР
Manoeuvrability of Ships (-	Lecture	2	3
Shallow Water Ship Hydro	dynamics (L1598)	Lecture	2	3
Module Responsible	Prof. Moustafa Abdel-Maksoud			
Admission Requirements	None			
Recommended Previous Knowledge	B.Sc. Schiffbau			
Educational Objectives	After taking part successfully, stud	dents have reached the follow	ing learning resu	ts
Professional Competence				
Knowledge	The students lern the motion equation and how to describe hydrodynamic forces. They'll will be able to develop methods for analysis of manoeuvring behaviour of ships and explaining the Nomoto equation. The students will know the common model tests as well as their assets and drawbacks. Furthermore, the students lern the basics of assessment and prognosis of ship manoeuvrabilit. Basics of characteristics of flows around ships in shallow water regarding ship propulsion and manoeuvrability will be aquired.			
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
	Independent Study Time 124, Stu	dy Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Naval Architecture and Ocean Er Ship and Offshore Technology: C Theoretical Mechanical Engineer Theoretical Mechanical Engir Compulsory	ore qualification: Elective Cor ing: Technical Complementar	npulsory	e Compulsor

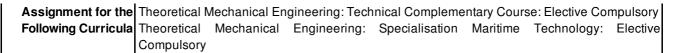


Course L1597: Manoe	uvrability of Ships		
Тур	Lecture		
Hrs/wk	2		
СР			
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Moustafa Abdel-Maksoud		
Language	DE/EN		
Cycle	WiSe		
Content	 coordinates & degrees of freedom governing equations of motion hydrodynamic forces & 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 		

Course L1598: Shallow	v Water 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

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Module M1165: S	hip Safety				
Courses					
Title		Тур	Hrs/wk	СР	
Ship Safety (L1267)		Lecture	2	4	
Ship Safety (L1268)		Recitation Section (large)	2	2	
Module Responsible	Prof. Stefan Krüger				
Admission Requirements	None				
Recommended Previous Knowledge	Ship Design, Hydrostatics, Statistical Pro	ocesses			
Educational Objectives	After taking part successfully, students h	ave reached the following lea	rning resu	lts	
Professional Competence					
Knowledge	The student shall lean to integrate safe the undertsnding and application of existing rules as well as th is targeted by a rule. Further, methods of demonstrating equiv	e understanding of the sfatey	concept a		
	he lectures starts with an overview abo maritime safety organizations are introduced, their re between prescriptive and performance based rules is tackled. Fo the rules on the deign is illustrated . Further, limitations of safte shown. Concepts of demonstrating equivalent levels of safe fields will be treated.	sponses and duties. Then, er different examples in ship y rules with respect to the p	the gere design, th physical ba	nal differend ne influence ackground a	
Skills	- Freeboard, water- and weathertight sul	odivisions, openings			
	- all aspects of intact stability, including s				
	- damage stability for passenger vessels including Stockholm agreement				
	- damage stbility fopr cargo vessels				
	 on board stability, inclining experiment Relevant manoevering information 	and stability booklet			
Personal					
Competence	The student learns to take responsibility	or the estatu of his designs			
	Responsible certification of technical de				
	Independent Study Time 124, Study Time				
Credit points					
Course achievement					
Examination					
Examination duration and scale	180 min				
	Naval Architecture and Ocean Engineer	ing: Core qualification: Comp	ulsory		



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

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	

Supplement Modules Core Studies

Allows to obtain missing basics form bachelor studies. For further information, see FSPO.

Module M0960: Mechanics IV (Kinetics II, Oscillations, Analytical Mechanics, Multibody Systems)

Courses			
Title	Тур	Hrs/wk	СР
Mechanics IV (Kinetics II, Oscillations, Analytical Mechanics, Multibody Systems) (L1137)	Lecture	3	3
Mechanics IV (Kinetics II, Oscillations, Analytical Mechanics, Multibody Systems) (L1138)	Recitation Section (small)	2	2
Mechanics IV (Kinetics II, Oscillations, Analytical Mechanics, Multibody Systems) (L1139)	Recitation Section (large)	1	1
Module Responsible Prof. Robert Seifried			
Admission			

Admission Requirements	None			
Recommended Previous Knowledge	Mathematics I-III and Mechanics I-III			
Educational Objectives	Atter taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	 The students can describe the axiomatic procedure used in mechanical contexts; explain important steps in model design; present technical knowledge. 			
Skills	 The students can explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems; apply basic methods to engineering problems; estimate the reach and boundaries of the methods and extend them to be applicable to wider problem sets. 			
Personal Competence				
Social Competence	The students can work in groups and support each other to overcome difficulties.			
Autonomy	Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	Compulsory Bonus No 20 %	Form Midterm	Description Wird nur im SoSe angeboten	
Examination	Written exam			
Examination duration and scale	120 min			

	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Biomedical
	Engineering: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Naval
	Architecture: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Mechanical
	Engineering: Compulsory
Assignment for the	General Engineering Science (English program, 7 semester): Specialisation Biomedical
Following Curricula	Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Naval
	Architecture: Compulsory
	Mechanical Engineering: Core qualification: Compulsory
	Mechatronics: Core qualification: Compulsory
	Naval Architecture: Core qualification: Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course Core Studies:
	Elective Compulsory

Course L1137: Mechanics IV (Kinetics II, Oscillations, Analytical Mechanics, Multibody Systems)		
Тур	D 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	 Simple impact problems Principles of analytical mechanics Elements of vibration theory Vibration of Multi-degree of freedom systems 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 (Kinetics II, Oscillations, Analytical Mechanics, Multibody Systems)		
Тур	Typ Recitation Section (small)	
Hrs/wk	Hrs/wk 2	
СР	CP 2	
Workload in Hours	load in Hours Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Robert Seifried	
Language	DE	
Cycle	Cycle SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1139: Mecha	ourse L1139: Mechanics IV (Kinetics II, Oscillations, Analytical Mechanics, Multibody Systems)	
Тур	Typ 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	

Hamburg Univer	sity of	Techno	logy

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module	1110034.	mainematics	IV

Courses

Courses				
Title		Тур	Hrs/wk	СР
Differential Equations 2 (P	artial Differential Equations) (L1043)	Lecture	2	1
	artial Differential Equations) (L1044)	Recitation Section (small)		1
	artial Differential Equations) (L1045)	Recitation Section (large)	1	1
Complex Functions (L103		Lecture	2	1
Complex Functions (L104		Recitation Section (small)		1
Complex Functions (L104	2)	Recitation Section (large)	1	1
Module Responsible	Prof. Anusch Taraz			
Admission Requirements	None			
Recommended Previous Knowledge	Mathematics 1 - III			
Educational Objectives	After taking part successfully, students	have reached the following lea	rning resu	lts
Professional Competence				
Knowledge	 Students can name the basic of them using appropriate example Students can discuss logical constrained of illustrating these connections They know proof strategies and 	es. onnections between these conc s with the help of examples.		
Skills	 Students can model problems in Mathematics IV 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	 Students are able to work toget a common language. In doing so, they can communication 	nicate new concepts accordin	g to the i	needs of the
Autonomy	 Students are capable of check own. They can specify open que them. Students have developed suffic a goal-oriented manner on hard 	estions precisely and know whe	ere to get l	nelp in solvin
	l			

	[]		
Workload in Hours	Independent Study Time 68, Study Time in Lecture 112		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	60 min (Complex Functions) + 60 min (Differential Equations 2)		
-	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory Computer Science: Specialisation Computational Mathematics: Elective Compulsory Electrical Engineering: Core qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering, Focus Mechatronics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Computational Science and Engineering: Specialisation Computer Science: Elective Compulsory Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory Mechanical Engineering: Specialisation Mechatronics: Compulsory Mechanical Engineering: Compulsory Naval Architecture: Core qualification: Compulsory Mecha		

Course L1043: Differential Equations 2 (Partial Differential Equations)		
Тур	Typ Lecture	
Hrs/wk	2	
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 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	Typ 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	Typ 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	2
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 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
Literature	 http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html

Course L1041: Comple	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	

ourse 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
Lecturer Language Cycle Content	Dozenten des Fachbereiches Mathematik der UHH DE SoSe See interlocking course

Courses				
Fitle ntroduction to Control Sys	stems (1.0654)	Typ Lecture	Hrs/wk 2	СР 4
ntroduction to Control Sys		Recitation Section (sr		2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Representation of signals and syste	ms in time and frequency dom	ain, Laplace t	ransform
Educational Objectives	After taking part successfully, studer	nts have reached the following	learning resu	lts
Professional Competence				
Knowledge	 Students can represent dynamic system behavior in time and frequency domain, an can in particular explain properties of first and second order systems They can explain the dynamics of simple control loops and interpret dynami properties in terms of frequency response and root locus They can explain the Nyquist stability criterion and the stability margins derived from it They can explain the role of the phase margin in analysis and synthesis of control loops They can explain the way a PID controller affects a control loop in terms of it frequency response They can explain issues arising when controllers designed in continuous time domai are implemented digitally 			
Skills	 Students can transform models of linear dynamic systems from time to frequence domain and vice versa They can simulate and assess the behavior of systems and control loops They can design PID controllers with the help of heuristic (Ziegler-Nichols) tuning rule They can analyze and synthesize simple control loops with the help of root locus an frequency response techniques They can calculate discrete-time approximations of controllers designed in continuous time and use it for digital implementation They can use standard software tools (Matlab Control Toolbox, Simulink) for carryin out these tasks 			
Personal Competence				
Social Competence	Students can work in small groups validate their controller designs	s to jointly solve technical pr	oblems, and e	experimenta
Autonomy	Students can obtain information from provided sources (lecture notes, softwa documentation, experiment guides) and use it when solving given problems. They can assess their knowledge in weekly on-line tests and thereby control their learning			

Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	1120 min
Assignment for the Following Curricula	IConoral Engineering Science (English program / competer): Specialization Rieprocess

Engineering, Focus Aircraft Systems Engineering: Compulsory General Engineering Science (English program, 7 semester): Special Engineering, Focus Materials in Engineering Sciences: Compulsory General Engineering Science (English program, 7 semester): Special Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (English program, 7 semester): Special Engineering, Focus Product Development and Production: Compulsory General Engineering Science (English program, 7 semester): Special Engineering, Focus Energy Systems: Compulsory Computational Science and Engineering: Core qualification: Compulsory Logistics and Mobility: Specialisation Engineering Science: Elective Comp Mechanical Engineering: Core qualification: Compulsory Mechatronics: Core qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Comp Theoretical Mechanical Engineering: Technical Complementary Cou Elective Compulsory Process Engineering: Core qualification: Compulsory	alisation Mechanical alisation Mechanical alisation Mechanical pulsory
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Typ	Lecture
Hrs/wk	
CP	
	T Independent Study Time 92, Study Time in Lecture 28
	Prof. Herbert Werner
Language	
Cycle	 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
Literature	 Werner, H., Lecture Notes "Introduction to Control Systems" G.F. Franklin, J.D. Powell and A. Emami-Naeini "Feedback Control of Dynam Systems", Addison Wesley, Reading, MA, 2009 K. Ogata "Modern Control Engineering", Fourth Edition, Prentice Hall, Upper Saddl River, NJ, 2010 R.C. Dorf and R.H. Bishop, "Modern Control Systems", Addison Wesley, Reading, M 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

Thesis

Master Thesis

Module M-002: N		
Courses		
Title	Typ Hrs/wk	СР
Module Responsible	Professoren der TUHH	
Admission Requirements		examination
Recommended Previous Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	S
Professional Competence		
Knowledge	 The students can use specialized knowledge (facts, theories, and meth subject competently on specialized issues. The students can explain in depth the relevant approaches and terminol or more areas of their subject, describing current developments and taking position on them. The students can place a research task in their subject area in its context a and critically assess the state of research. 	logies in one g up a critica
Skills	 The students are able: To select, apply and, if necessary, develop further methods that are suitab the specialized problem in question. To apply knowledge they have acquired and methods they have learnt in their studies to complex and/or incompletely defined problems in a solu way. To develop new scientific findings in their subject area and subject then assessment. 	the course o ition-oriented
Personal Competence		
Social Competence	 Students can Both in writing and orally outline a scientific issue for an expert audienc understandably and in a structured way. Deal with issues competently in an expert discussion and answer them 	in a manner
Autonomy	 To structure a project of their own in work packages and to work them off a To work their way in depth into a largely unknown subject and to [660] 	

	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	30
Course achievement	None
Examination	Thesis
Examination duration and scale	According to General Regulations
Assignment for the Following Curricula	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory 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 Global Innovation Management: Thesis: Compulsory Information and Communication Systems: 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 Mathematical Modelling in Engineering: Theory, Numerics, Applications: Thesis: Compulsory Mathematical Modelling in Engineering: Thesis: Compulsory Mathematical Engineering and Management: Thesis: Compulsory Mechanical 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 Ship and Offshore Technology: Thesis: Compulsory Process Engineering: Thesis: Compulsory Water and Environmental Engineering: Thesis: Compulsory Water and Environmental Engineering: Thesis: Compulsory