

Module Manual

Master of Science (M.Sc.) Mechatronics

Cohort: Winter Term 2021 Updated: 19th October 2023

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Program description

Content

The consecutive international master program "Mechatronics" extends the education in engineering, mathematics and natural science of the bachelor studies. It provides systematic, scientific and autonomous problem solving capabilities needed in industry and research.

The program covers the methods of computation, design and implementation of mechatronic systems. Students specialize in one out of two concentrations and develop the ability to work in the interfaces of the interconnected sub-disciplines. Based on personal interest, students are able to adapt their study programs within a broad catalogue of elective courses.

Career prospects

The consecutive international Master course "Mechatronics" prepares graduates for a wide range of job profiles in mechatronics engineering.

Graduates can work directly in their specialization area: System Design and Intelligent Systems and Robotics.

Additionally graduates have a multifaceted knowledge of methods for interdisciplinary topics.

Graduates may decide for direct entry into companies or to take up academic careers, e.g. Ph.D. studies, in universities or other research institutions. In companies they can take up jobs as specialists or subsequently qualify for demanding management tasks in the technical area (e.g. project, group, or team leader; R&D director).

The program is designed to be universal and allows graduates to work in a variety of different industrial sectors and with different projects.

Learning target

Graduates of the program are able to transfer the individually acquired specialized knowledge to new, unknown topics, to comprehend, to analyze and to scientifically solve complex problems of their discipline. They can find missing information and plan as well as execute theoretical and experimental studies. They are able to judge, evaluate and question scientific engineering results critically as well as making decisions based on this foundation and draw further conclusions. They are able to act methodically, to organize smaller projects, to select new technologies and scientific methods and to advance these further, if necessary.

Graduates can develop and document new ideas and solutions, independently or in teams. They are capable of presenting and discussing results to and with professionals. They can estimate their own strengths and weaknesses as well as possible consequences of their actions. They are capable of familiarizing themselves with complex tasks, defining new tasks and developing the necessary knowledge to solve them using systematically applied, appropriate means.

System Design

In the system design specialization, graduates learn how to work systematically and methodically on challenging design tasks.

They have broad knowledge of new development methods, are able to select appropriate solution strategies and use these autonomously to develop new products. They are qualified to use the approaches of integrated system development, such as simulation or modern testing procedures.

Intelligent Systems and Robotics

In the intelligent systems and robotics specialization, graduates learn how to work systematically and methodically on challenging tasks.

They have broad knowledge of automation and simulation and are able to select appropriate solution strategies and use these autonomously to develop intelligent systems.

Program structure

The course is designed modularly and is based on the university-wide standardized course structure with uniform module sizes (multiples of six credit points (CP)).

The program combines the disciplines of mechanical and electrical engineering and supports concentration in interdisciplinary fields of system design and system implementation.

All modules in the first semester are mandatory. This helps especially students from abroad to familiarize themselves with the university and culture.

Afterwards the students can broadly personalize their studies due to the high number and variety of elective courses.

In the common core skills, students take the following modules:

- Finite element analysis and Vibration theory (12 CP)
- Theory and design of control systems and Design and implementation of software systems
- Robotics and Mechatronic system
- Complementary courses business and management (catalogue) (6 CP)
- Nontechnical elective complementary courses (catalogue) (6 CP).

Students specialize by selecting one of the following areas, each covering 30 credit points:

- System designIntelligent systems and robotics.
- Within each area of specialization 30 credits can be chosen form a module catalog containing modules with a size of six credits. Instead, open modules

can be attend to the maximum extent of twelve credit points, in which smaller specialized courses can be combined, individually.

Students write a master thesis and one additional scientific project work.

- Project work (12 CP)
- Master thesis (30 CP)

Core Qualification

Module M0523: Busine	ess & Management
Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	 Students are able to find their way 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
dmission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
rofessional Competence	
Knowledge	The Nontechnical Academic Programms (NTA)
	imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover Self-reliance, self-management, collaboration and professional and personnel management competences. The depart implements these training objectives in its teaching architecture , in its teaching and learning arrangements , in teac areas and by means of teaching offerings in which students can qualify by opting for specific competences and a compet level at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontecl complementary courses.
	The Learning Architecture
	consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontecl academic programms follow the specific profiling of TUHH degree courses.
	The learning architecture demands and trains independent educational planning as regards the individual developme competences. It also provides orientation knowledge in the form of "profiles".
	The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in o two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making transition from school to university and in order to encourage individually planned semesters abroad, there is no obligati study these subjects in one or two specific semesters during the course of studies.
	Teaching and Learning Arrangements
	provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of de with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliber encouraged in specific courses.
	Fields of Teaching
	are based on research findings from the academic disciplines cultural studies, social studies, arts, historical str communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the v semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and star in a goal-oriented way.
	The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.
	The Competence Level
	of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. I differences are reflected in the practical examples used, in content topics that refer to different professional application con 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 leade 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 i 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 represent 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.
CL:II-	
SKIIIS	Professional Competence (Skills)
	 In selected sub-areas students can apply basic and specific methods of the said scientific disciplines, aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specific 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 technical relationship to the subject.

Personal Competence

Social Competence Personal Competences (Social Skills)

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

odule M0563: Robot	lics			
ourses				
itle		Түр	Hrs/wk	СР
Robotics: Modelling and Control (LC	168)	Integrated Lecture	4	4
Robotics: Modelling and Control (L1		Project-/problem-based Learning	2	2
Module Responsible	Dr. Martin Gomse			
Admission Requirements	None			
Recommended Previous	Fundamentals of electrical engineering			
Knowledge	Broad knowledge of mechanics			
	Fundamentals of control theory			
Educational Objectives	After taking part successfully, students have read	ched the following learning results		
Professional Competence				
Knowledge	Students are able to describe fundamental prope	erties of robots and solution approaches for mult	iple problems	in robotics.
Skills	Students are able to derive and solve equations of	of motion for various manipulators.		
	Students can generate trajectories in various coordinate systems.			
	Students can design linear and partially nonlinea	r controllers for robotic manipulators.		
Personal Competence				
Social Competence	Students are able to work goal-oriented in small	mixed groups.		
Autonomy	Students are able to recognize and improve know	vledge deficits independently.		
	With instructor assistance, students are able to e	evaluate their own knowledge level and define a	further course	e of study.
Workload in Hours	Independent Study Time 96, Study Time in Lectu	re 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Aircraft Systems Engineering: Core Qualification:	Elective Compulsory		
Following Curricula	Aircraft Systems Engineering: Specialisation Aircr	raft Systems: Elective Compulsory		
	International Management and Engineering: Spec	cialisation II. Mechatronics: Elective Compulsory		
	International Management and Engineering: Spec	cialisation II. Product Development and Production	on: Elective C	ompulsory
	Mechanical Engineering and Management: Core (Qualification: Compulsory		
	Mechatronics: Core Qualification: Compulsory			
	Product Development, Materials and Production:	Specialisation Product Development: Elective Co	ompulsory	
	Product Development, Materials and Production:	Specialisation Production: Elective Compulsory		
	Product Development, Materials and Production:	Specialisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation	on Robotics and Computer Science: Elective Com	volsorv	

Course L0168: Robotics: Modelling and Control				
Тур	Integrated Lecture			
Hrs/wk	4			
CP				
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56			
Lecturer	Dr. Martin Gomse			
Language	EN			
Cycle	WiSe			
Content	Fundamental kinematics of rigid body systems			
	Newton-Euler equations for manipulators			
	Trajectory generation			
	Linear and nonlinear control of robots			
Literature	Craig, John J.: Introduction to Robotics Mechanics and Control, Third Edition, Prentice Hall. ISBN 0201-54361-3			
	Spong, Mark W.; Hutchinson, Seth; Vidyasagar, M. : Robot Modeling and Control. WILEY. ISBN 0-471-64990-2			

ourse L1305: Robotics: Modelling and Control				
Тур	t-/problem-based Learning			
Hrs/wk	2			
CP	2			
Workload in Hours	dent Study Time 32, Study Time in Lecture 28			
Lecturer	Dr. Martin Gomse			
Language	EN			
Cycle	Cycle WiSe			
Content	See interlocking course			
Literature	See interlocking course			

Courses				
litle		Typ	Hrs/wk	СР
inite Element Methods (L0291)		Typ Lecture	2	3
inite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements				
Recommended Previous		lechanics II (Hydrostatics, Kinematics, Dyna	amics)	
Knowledge				
Educational Objections		ad the stall and a sub-section supervise		
Educational Objectives Professional Competence		ed the following learning results		
Knowledge			nt method and	are able to give
Skills	The students are capable to handle engineering p system matrices, and solving the resulting system		nents, assemblin	g the correspond
	Students can work in small groups on specific prob The students are able to independently solve c		evelop own finit	e element routir
Workload in Hours	Independent Study Time 124, Study Time in Lectu	re 56		
Credit points	6			
	6 Compulsory Bonus Form	re 56 Description		
Credit points Course achievement	6 Compulsory Bonus Form No 20 % Midterm			
Credit points Course achievement Examination	6 Compulsory Bonus Form No 20 % Midterm Written exam			
Credit points Course achievement Examination Examination duration and	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min			
Credit points Course achievement Examination Examination duration and scale	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min			
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min Civil Engineering: Core Qualification: Compulsory	Description		
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min	Description		
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Comp	Description ulsory ft Systems: Elective Compulsory		
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Comp Aircraft Systems Engineering: Specialisation Aircra	Description ulsory ft Systems: Elective Compulsory ansportation Systems: Elective Compulsory		
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Comp Aircraft Systems Engineering: Specialisation Air Tra- Aircraft Systems Engineering: Specialisation Air Tra-	Description ulsory ft Systems: Elective Compulsory ansportation Systems: Elective Compulsory lective Compulsory		
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Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Air Traircraft Systems Engineering: Core Qualification: Elective: Elective Engineering: Core Qualification: Election: Election Air Traircraft Systems Engineering: Core Qualification: Election: Electi	Description ulsory ft Systems: Elective Compulsory ansportation Systems: Elective Compulsory lective Compulsory alisation II. Mechatronics: Elective Compulso		ompulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Air Traircraft Systems Engineering: Core Qualification: Elective: Elective Engineering: Specialisation Air Traircraft Systems Engineering: Core Qualification: Elective Election: Elective Election: Elective Election: Elective Engineering: Specialisation Air Traircraft Systems Engineering: Specialisation Air Traircraft Systems Engineering: Core Qualification: Elective E	Description ulsory ft Systems: Elective Compulsory ansportation Systems: Elective Compulsory lective Compulsory alisation II. Mechatronics: Elective Compulso alisation II. Product Development and Produ		ompulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Air Tr Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation Air Systems Engineering: Core Qualification: Elective Compulsory Biomedical Engineering: Specialisation Implants ar	Description ulsory ft Systems: Elective Compulsory ansportation Systems: Elective Compulsory lective Compulsory alisation II. Mechatronics: Elective Compulso alisation II. Product Development and Produ al Endoprostheses: Compulsory	ction: Elective Co	ompulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Comp Aircraft Systems Engineering: Specialisation Aircra Aircraft Systems Engineering: Specialisation Air Tr Aircraft Systems Engineering: Core Qualification: E International Management and Engineering: Specialisation E International Management and Engineering: Specialisation Implants ar Biomedical Engineering: Specialisation Implants ar	Description ulsory ft Systems: Elective Compulsory ansportation Systems: Elective Compulsory lective Compulsory alisation II. Mechatronics: Elective Compulso alisation II. Product Development and Produ al Endoprostheses: Compulsory nt and Business Administration: Elective Co	ction: Elective Co	ompulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Comp Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Air Tr Aircraft Systems Engineering: Core Qualification: Elective Comp International Management and Engineering: Specialisation Air Tr Aircraft Systems Engineering: Core Qualification: Elective Comp International Management and Engineering: Specialisation Air Tr Aircraft Systems Engineering: Core Qualification: Elective Comp International Management and Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation Manageme Biomedical Engineering: Specialisation Implants ar Biomedical Engineering: Specialisation Manageme	Description ulsory ft Systems: Elective Compulsory ansportation Systems: Elective Compulsory alisation II. Mechatronics: Elective Compulsor alisation II. Product Development and Produ td Endoprostheses: Compulsory nt and Business Administration: Elective Comp the computation of the compulsor of the compulsor of the computation of the compulsor of the computation of the co	ction: Elective Co mpulsory pulsory	ompulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min 120 min	Description ulsory ft Systems: Elective Compulsory ansportation Systems: Elective Compulsory alisation II. Mechatronics: Elective Compulsor alisation II. Product Development and Produ al Endoprostheses: Compulsory nt and Business Administration: Elective Comp gans and Regenerative Medicine: Elective Comp	ction: Elective Co mpulsory pulsory	ompulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Comp Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Air Tr Aircraft Systems Engineering: Core Qualification: Elective Comp International Management and Engineering: Specialisation Air Tr Aircraft Systems Engineering: Core Qualification: Elective Comp International Management and Engineering: Specialisation Air Tr Aircraft Systems Engineering: Core Qualification: Elective Comp International Management and Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation Manageme Biomedical Engineering: Specialisation Implants ar Biomedical Engineering: Specialisation Manageme	Description Ulsory ft Systems: Elective Compulsory ansportation Systems: Elective Compulsory alisation II. Mechatronics: Elective Compulsor alisation II. Product Development and Produ al Endoprostheses: Compulsory nt and Business Administration: Elective Comp gans and Regenerative Medicine: Elective Co ore Qualification: Compulsory	ction: Elective Co mpulsory pulsory	pmpulsory

Course L0291: Finite Element	z 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		

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

Courses				
Title		Тур	Hrs/wk	СР
Control Systems Theory and Desig		Lecture	2	4
Control Systems Theory and Desig		Recitation Section (small)	2	2
Module Responsible				
Admission Requirements				
	Introduction to Control Systems			
Knowledge	After taking part successfully, students bay	e vesseled the fellowing leaveling vessilts		
	After taking part successfully, students have	e reached the following learning results		
Professional Competence Knowledge				
Knowledge	Students can explain how linear dyn	namic systems are represented as state space r	nodels; they can	interpret the sys
	response to initial states or external	excitation as trajectories in state space		
	They can explain the system property	ties controllability and observability, and their re	lationship to state	e feedback and s
	estimation, respectively			
	They can explain the significance of a			
		te feedback and how it can be used to achieve tra	acking and distur	bance rejection
	 They can extend all of the above to n They can explain the z transform and 			
		I its relationship with the Laplace Transform and transfer function models of discrete-time sy:	tems	
		lentification of ARX models of dynamic systems, a		ification problem
	be solved by solving a normal equation			
		nodel can be constructed from a discrete-time im	pulse response	
CL 11				
Skills		tion models into state space models and vice ver	sa	
	They can assess controllability and of	bservability and construct minimal realisations		
	They can design LQG controllers for r	nultivariable plants		
	• They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriate			
	for a given sampling rate			
		odels and state space models of dynamic system		
		using standard software tools (Matlab Control To	oolbox, System Id	lentification Toolb
	Simulink)			
Personal Competence				
Social Competence	Students can work in small groups on specif	fic problems to arrive at joint solutions.		
Autonomy	Students can obtain information from prov	vided sources (lecture notes, software documen	tation experimer	at quides) and us
Autonomy	when solving given problems.	nded sources (lecture notes, software documen	tation, experimer	it guides) and us
	when solving given problems.			
	They can assess their knowledge in weekly	on-line tests and thereby control their learning pr	ogress.	
Workload in Hours	Independent Study Time 124, Study Time ir	n Lecture 56		
Credit points	6			
Course achievement				
	Written exam			
Examination duration and	120 min			
scale	Electrical Engineering: Core Qualification: C			
5	Energy Systems: Core Qualification: Elective	1 5		
Following Curricula	Aircraft Systems Engineering: Core Qualification			
		ecialisation II. Engineering Science: Elective Com	pulsorv	
		: Specialisation II. Electrical Engineering: Elective		
		: Specialisation II. Mechatronics: Elective Compute		
		Specialisation Mechatronics: Elective Compulsory	-	
	Mechatronics: Core Qualification: Compulso	ry		
	Biomedical Engineering: Specialisation Artif	icial Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Impl	ants and Endoprostheses: Elective Compulsory		
		ical Technology and Control Theory: Compulsory		
		agement and Business Administration: Elective C	ompulsory	
		tion: Core Qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Core Q			

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

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

Courses					
Title		Тур	Hrs/wk	СР	
Design and Implementation of Software Systems (L1657) Design and Implementation of Software Systems (L1658)		Lecture Practical Course	2	3	
Module Responsible	-	Tractical course	2	5	
Admission Requirements					
	- Imperativ programming languages (C, P	ascal, Fortran or similar)			
Knowledge	- Simple data types (integer, double, char, boolean), arrays, if-then-else, for, while, procedure and function calls				
Educational Objectives	After taking part successfully, students ha	ave 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 the combination of Hard- and Softwa and the interfaces.				
Personal Competence					
Social Competence	Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities and define task with the team.				
Autonomy	Students are able to solve individually exercises related to this lecture with instructional direction. Students are able to platexecute and summarize a mechatronic experiment.				
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 min				
scale					
5	Mechatronics: Core Qualification: Comput	sory			
Following Curricula					

Course L1657: Design and In	nplementation of Software Systems
Тур	Lecture
Hrs/wk	2
CP	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 Blue]" David J. Barnes & Michael Kölling Prentice Hall/ Pearson Education; 2003, ISBN 0-13-044929-6

Course L1658: Design and In	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	NN		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title		True		CD
Vibration Theory (L0701)		Typ Integrated Lecture	Hrs/wk 4	CP 6
-	Prof. Norbert Hoffmann	5		
Admission Requirements				
Recommended Previous Knowledge	 Calculus Linear Algebra Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have read	hed the following learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts	of Vibration Theory and develop them fur	ther.	
Skills	Students are able to denote methods of Vibration	Theory and develop them further.		
Personal Competence				
Social Competence	Students can reach working results also in group	5.		
Autonomy	Students are able to approach individually resear	ch tasks in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lect	ure 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Energy Systems: Core Qualification: Elective Con	pulsory		
Following Curricula	International Management and Engineering: Spe Mechanical Engineering and Management: Speci Mechatronics: Core Qualification: Compulsory	alisation Mechatronics: Elective Compulso	pry	
	Biomedical Engineering: Specialisation Artificial G Biomedical Engineering: Specialisation Implants Biomedical Engineering: Specialisation Medical T Biomedical Engineering: Specialisation Managem	and Endoprostheses: Elective Compulsory echnology and Control Theory: Elective Co ent and Business Administration: Elective	, ompulsory	
	Product Development, Materials and Production: Naval Architecture and Ocean Engineering: Core Theoretical Mechanical Engineering: Core Qualifi	Qualification: Elective Compulsory		

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

Courses			
Title	Typ Hrs/wk CP		
Module Responsible	Dozenten des Studiengangs		
Admission Requirements	None		
Recommended Previous Knowledge	Subjects of the program of studies.		
Ţ	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	The students are able to demonstrate their detailed knowledge in the field of mechatronics engineering. They can exemplify the state of technology and application and discuss critically in the context of actual problems and general conditions of science and society.		
	The students can develop solving strategies and approaches for fundamental and practical problems in mechatronics engineerir They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of scien and society.		
Skills	Scientific work techniques that are used can be described and critically reviewed. The students are able to independently select methods for the project work and to justify this choice. They can explain how the methods relate to the field of work and how the context of application has to be adjusted. General findings and furth developments may essentially be outlined.		
Personal Competence			
Social Competence	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to the colleagues.		
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the giv deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedba from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology		
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0		
Credit points	12		
Course achievement	None		
Examination	Study work		
Examination duration and scale	It. FSPO		
Assignment for the Following Curricula	Mechatronics: Core Qualification: Compulsory		

Specialization Intelligent Systems and Robotics

In the intelligent systems and robotics specialization, graduates learn how to work systematically and methodically on challenging tasks.

They have broad knowledge of automation and simulation and are able to select appropriate solution strategies and use these autonomously to develop intelligent systems.

Module M0692: Appro	oximation and Stability			
Courses				
Title		Тур	Hrs/wk	СР
Approximation and Stability (L0487	7)	Lecture	3	4
Approximation and Stability (L0488	3)	Recitation Section (small)	1	2
Module Responsible	Prof. Marko Lindner			
Admission Requirements	None			
Recommended Previous	- Lincor Algobro, systems of lincor	envetione loopt enverse problems, since values, sin		
Knowledge	 Linear Algebra: systems of linear of Analysis: sequences, series, differ 	equations, least squares problems, eigenvalues, sir	igular values	
	 Analysis, sequences, series, unier 	entiation, integration		
Educational Objectives	After taking part successfully, students h	nave reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	a skatch and intervalate basis sones	anks of functional analysis (Hilbort and so analysis)	\	
		epts of functional analysis (Hilbert space, operators),	
	 name and understand concrete ap name and explain basic stability t 			
		tions numbers and methods of regularisation		
	• uiscuss spectrar quantities, condit	ions numbers and methods of regularisation		
Skills	Students are able to			
	 apply basic results from functiona 	l analysis.		
	 apply approximation methods, 			
	apply stability theorems,			
	 compute spectral quantities, 			
	 apply regularisation methods. 			
Personal Competence				
Social Competence	Students are able to solve specific proble	ems in groups and to present their results appropri	ately (e.g. as a sen	ninar presentation).
Autonomy				
Autonomy	Students are capable of checking	their understanding of complex concepts on their	r own. They can sp	pecify open questio
	precisely and know where to get h	help in solving them.		
	Students have developed sufficient	ent persistence to be able to work for longer peri	ods in a goal-orier	nted manner on ha
	problems.			
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points	6			
Course achievement	Compulsory Bonus Form	Description		
	Yes None Presentation			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Con	ntrol and Power Systems Engineering: Elective Com	npulsory	
Following Curricula	Mechatronics: Specialisation Intelligent S	Systems and Robotics: Elective Compulsory		
	Technomathematics: Specialisation I. Ma	athematics: Elective Compulsory		
	Theoretical Mechanical Engineering: Spe	ecialisation Robotics and Computer Science: Elective	e Compulsory	

Course L0487: Approximation	n and Stability
Тур	Lecture
Hrs/wk	3
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 on C*-algebras convergence of condition numbers
	 convergence of condition numbers convergence of spectral quantities: spectrum, eigen values, singular values, pseudospectra
	 regularisation methods (truncated SVD, Tichonov)
Literature	R. Hagen, S. Roch, B. Silbermann: C*-Algebras in Numerical Analysis
	 H. W. Alt: Lineare Funktionalanalysis
	M. Lindner: Infinite matrices and their finite sections

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

Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and	concepts in Nonlinear Dynamics and t	o develop and resea	arch new terms a
	concepts.			
Skills	Students are able to apply existing methods and	procesures of Nonlinear Dynamics and to	develop novel meth	ods and procedur
Personal Competence				
Social Competence	Students can reach working results also in group	s.		
Autonomy	Students are able to approach given research ta	sks individually and to identify and follow	up novel research ta	sks by themselves
Workload in Hours	Independent Study Time 124, Study Time in Lec	ure 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Aircraft Systems Engineering: Core Qualification	Elective Compulsory		
Following Curricula	International Management and Engineering: Spe	cialisation II. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory			
	Mechatronics: Specialisation System Design: Ele	ctive Compulsory		
	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial	Organs and Regenerative Medicine: Electi	ve Compulsory	
	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Elective Compulsory	,	
	Biomedical Engineering: Specialisation Medical T	echnology and Control Theory: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Managen	ent and Business Administration: Elective	Compulsory	
	Product Development, Materials and Production:	Core Qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Core Qualifi	cation: Elective Compulsory		

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

•				
Courses				
Title		Тур	Hrs/wk	СР
Optimal and Robust Control (L0658 Optimal and Robust Control (L0659		Lecture Recitation Section (small)	2	3 3
•		Recitation Section (Smail)	2	5
Module Responsible				
Admission Requirements	None			
Recommended Previous	Classical control (frequency response, root locus)			
Knowledge	State space methods			
	Linear algebra, singular value decomposition			
Educational Objectives	After taking part as accordingly students have reached the f			
	After taking part successfully, students have reached the f	bilowing learning results		
Professional Competence				
Knowledge	Students can explain the significance of the matrix I	Riccati equation for the solution of I	LQ problems.	
	They can explain the duality between optimal state	feedback and optimal state estima	tion.	
	 They can explain how the H2 and H-infinity norms a 	re used to represent stability and p	erformance cons	traints.
	 They can explain how an LQG design problem can b 	e formulated as special case of an	H2 design proble	m.
	 They can explain how model uncertainty can be replaced. 	presented in a way that lends itself	to robust control	er design
	 They can explain how - based on the small gain the 	eorem - a robust controller can gu	arantee stability	and performance
	an uncertain plant.			
	 They understand how analysis and synthesis condition 	ons on feedback loops can be repre	esented as linear	matrix inequalitie
Skills				
	 Students are capable of designing and tuning LQG c 	ontrollers for multivariable plant m	odels.	
	They are capable of representing a H2 or H-infinity	design problem in the form of a ge	neralized plant, a	nd of using stand
	software tools for solving it.			
	They are capable of translating time and frequency	•	loops into const	raints on closed-lo
	sensitivity functions, and of carrying out a mixed-se		and of desired	and a sector of a laterate
	 They are capable of constructing an LFT uncertain reduct controller 	ty model for an uncertain system	, and of designin	ig a mixed-object
	robust controller.	acis conditions as linear matrix inc	qualities (LMI)	nd of using stands
	 They are capable of formulating analysis and synth LMI-solvers for solving them. 		qualities (LMI), a	nu or using stanua
	 They can carry out all of the above using standard s 	oftware tools (Matlab robust contro	l toolbox)	
Personal Competence				
Social Competence	Students can work in small groups on specific problems to	arrive at joint solutions.		
Autonomy	Students are able to find required information in sources p	rovided (lecture notes, literature, s	oftware docume	ntation) and use it
	solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Control and Power Sy	stems Engineering: Elective Comp	ulsorv	
-	Energy Systems: Core Qualification: Elective Compulsory			
3 • • • • •	Aircraft Systems Engineering: Core Qualification: Elective (Compulsory		
	Mechatronics: Specialisation Intelligent Systems and Robot			
	Mechatronics: Specialisation System Design: Elective Com			
	Biomedical Engineering: Specialisation Artificial Organs an	d Regenerative Medicine: Elective (Compulsory	
	Biomedical Engineering: Specialisation Implants and Endop	prostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Com	oulsory	
	Biomedical Engineering: Specialisation Management and B	usiness Administration: Elective Co	mpulsory	
	Product Development, Materials and Production: Specialisa	tion Product Development: Elective	e Compulsory	
	Product Development, Materials and Production: Specialisa	tion Production: Elective Compulso	ry	
	Product Development, Materials and Production: Specialisa	tion Materials: Elective Compulsory	/	
	Theoretical Mechanical Engineering: Core Qualification: Ele	ective Compulsory		

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

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

Courses				
Title		Тур	Hrs/wk	СР
Numerical Treatment of Ordinary D Numerical Treatment of Ordinary D		Lecture Recitation Section (small)	2	3 3
Module Responsible			L	5
Admission Requirements				
Recommended Previous				
Knowledge		lierende (deutsch oder englisch) oder Analysis &	Lineare Algebra	+ II sowie Analysi
	für Technomathematiker • Basic MATLAB knowledge			
Educational Objectives	After taking part successfully, students hav	ve reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	 list numerical methods for the solution 	on of ordinary differential equations and explain	heir core ideas.	
		r the treated numerical methods (including the		ied to the underly
	problem),			
	 explain aspects regarding the practic 	cal execution of a method.		
	 select the appropriate numerical r 	method for concrete problems, implement the	numerical algo	rithms efficiently
	interpret the numerical results			
Skills	Students are able to			
	 implement (MATLAB), apply and com 	npare numerical methods for the solution of ordin	arv differential e	quations.
		r of numerical methods with respect to the posed		
		ble solution approach, if necessary by the compo		
	this approach and to critically evalua	ate the results.		
Personal Competence				
Social Competence	Students are able to			
	work together in heterogeneously co	omposed teams (i.e., teams from different study	programs and ba	ckground knowled
	explain theoretical foundations and s	support each other with practical aspects regardi	ng the implement	tation of algorithms
Autonomy	Students are capable			
Autonomy				
		eoretical and practical excercises are better solve	ed individually or	in a team,
	 to assess their individual progress ar 	nd, if necessary, to ask questions and seek help.		
Workload in Hours	Independent Study Time 124, Study Time in	n Lecture 56		
Credit points				
Course achievement				
Examination				
Examination duration and scale	90 min			
	Bioprocess Engineering: Specialisation A - (General Bioprocess Engineering: Elective Compul	sorv	
-		cialisation Chemical Process Engineering: Elective	-	
· · · · · · · · · · · · · · · · · · ·		cialisation General Process Engineering: Elective		
	Computer Science: Specialisation III. Mathe		-	
	Electrical Engineering: Specialisation Control	ol and Power Systems Engineering: Elective Com	pulsory	
	Energy Systems: Core Qualification: Electiv	ve Compulsory		
	Aircraft Systems Engineering: Core Qualific			
		on II. Numerical - Modelling Training: Compulsory		
	Mechatronics: Specialisation Intelligent Sys	stems and Robotics: Elective Compulsory		
	, , ,			
	Technomathematics: Specialisation I. Mathe			
	Technomathematics: Specialisation I. Mathematics Theoretical Mechanical Engineering: Core C			

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

Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Daniel Ruprecht
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Courses				
		T	I los toda	<u></u>
Title Systems Engineering (L1547)		Typ Lecture	Hrs/wk 3	CP 4
Systems Engineering (L1547)		Recitation Section (large)	1	2
Module Responsible	Prof. Ralf God	neeration Section (arge)	-	-
Admission Requirements	None			
Recommended Previous				
Knowledge	Basic knowledge in: • Mathematics			
Kilowiedge	Mathematics Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Control Systems			
	Previous knowledge in:			
	Aircraft Cabin Systems			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
	After taking part successfully, students have reached	the following learning results		
Professional Competence	Chudanha ana akia ha			
Knowledge	Students are able to:	atheda and tools for the development of	f. commissi Custom	-
	understand systems engineering process models, n		r complex System	15
	describe innovation processes and the need for tec			
	 explain the aircraft development process and the p explain the system development process, including 			
	 explain the system development process, including identify environmental conditions and test procedu 			
			oonto onginooring	(MPDE)
	 value the methodology of requirements-based engi 	leening (KBE) and model-based requirem	nents engineering	(MBRE)
Skills	Students are able to:			
	 plan the process for the development of complex S 	stems		
	 organize the development phases and developmen 	Tasks		
	 assign required business activities and technical Ta 	sks		
	 apply systems engineering methods and tools 			
Personal Competence				
-	Students are able to:			
Social Competence		ant team and integrate themselves with	their role in the e	vorall process
	 understand their responsibilities within a developm 	ent team and integrate themselves with	their role in the o	verall process
Autonomy	Students are able to:			
	 interact and communicate in a development team value 	hich has distributed tasks		
	Independent Study Time 124, Study Time in Lecture	66		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration and	120 Minutes			
scale				
Assignment for the	Aircraft Systems Engineering: Core Qualification: Con	pulsory		
Following Curricula			-	
	International Management and Engineering: Specialis		iction: Elective Co	ompulsory
	Mechatronics: Specialisation System Design: Elective			
	Mechatronics: Specialisation Intelligent Systems and			
	Product Development, Materials and Production: Spec		3	
	Product Development, Materials and Production: Spec		-	
	Preduct Development Meterials and Dreduction, Cro-	inlightion Materials, Elective Compulson		
	Product Development, Materials and Production: Spec Theoretical Mechanical Engineering: Specialisation Ai			

Course L1547: Systems Engir	neering
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and 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
	l

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

Courses			
itle	Тур	Hrs/wk	СР
Module Responsible	NN		
Admission Requirements	None		
Recommended Previous	See selected module according to FSPO		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	see selected module according to FSPO		
Skills	see selected module according to FSPO		
_			
Personal Competence			
Social Competence	see selected module according to FSPO		
4	and a last diversities to 5000		
Autonomy	see selected module according to FSPO		
Workload in Hours	Depends on choice of courses		
Credit points			
	Mechatronics: Specialisation System Design: Elective Compulsory		
-	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory		

Courses			
Title	Тур	Hrs/wk	СР
Applied Automation (L1592)	Project-/problem-based Learning	3	3
Ergonomics (L0653)	Lecture	2	3
Advanced Training Course SE-ZER	(L2739) Project-/problem-based Learning	2	3
Development Management for Med	hatronics (L1512) Lecture	2	3
Fatigue & Damage Tolerance (L03)	.0) Lecture	2	3
Industry 4.0 for engineers (L2012)	Lecture	2	3
Microcontroller Circuits: Implement	ation in Hardware and Software (L0087) Seminar	2	2
Microsystems Technology (L0724)	Lecture	2	4
Model-Based Systems Engineering	(MBSE) with SysML/UML (L1551) Project-/problem-based Learning	3	3
Sustainable Industrial Production (I	.2863) Lecture	2	3
Process Measurement Engineering	(L1077) Lecture	2	3
Process Measurement Engineering		1	1
Feedback Control in Medical Techn		2	3
Applied Dynamics (L1630)	Lecture	2	3
Module Responsible	NN		
Admission Requirements	None		
Recommended Previous			
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	Frice taking part succession, stadents have reached the following fearming results		
-			
Knowledge			
	 Students are able to express their extended knowledge and discuss the connection of c 	ifferent specia	I fields or applic
	 Students are able to express their extended knowledge and discuss the connection of c areas of mechatronics 	ifferent specia	I fields or applic
	areas of mechatronics	ifferent specia	l fields or applic
		ifferent specia	I fields or applic
	areas of mechatronics	ifferent specia	I fields or applic
	areas of mechatronics	ifferent specia	I fields or applic
Skills	areas of mechatronics Students are qualified to connect different special fields with each other 		I fields or applic
Skills	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected 	areas	
Skills	areas of mechatronics Students are qualified to connect different special fields with each other 	areas	
Skills	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected 	areas	
Skills	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected 	areas	
Skills Personal Competence	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected 	areas	
	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can developed 	areas	
Personal Competence	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can developed 	l areas op own solution	
Personal Competence Social Competence	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can developed 	l areas op own solution	
Personal Competence Social Competence	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can developed 	l areas op own solution	
Personal Competence Social Competence	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can developed 	l areas op own solution	
Personal Competence Social Competence Autonomy	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can developed 	l areas op own solution	
Personal Competence Social Competence Autonomy	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can develor None Students are able to develop their knowledge and skills by autonomous election of courss 	l areas op own solution	
Personal Competence Social Competence Autonomy Workload in Hours Credit points	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can develor None Students are able to develop their knowledge and skills by autonomous election of courss 	l areas op own solution	

Course L159	2: Applied Automation
Тур	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in	Independent Study Time 48, Study Time in Lecture 42
Hours	
Examination	Mündliche Prüfung
Form	
Examination	30 Minuten
duration	
and scale	
Lecturer	Prof. Thorsten Schüppstuhl
Language	DE
Cycle	WiSe
Content	-Project Based Learning -Robot Operating System -Robot structure and description -Motion description -Calibration -Accuracy
Literature	John J. Craig Introduction to Robotics - Mechanics and Control ISBN: 0131236296 Pearson Education, Inc., 2005 Stefan Hesse Grundlagen der Handhabungstechnik ISBN: 3446418725 München Hanser, 2010 K. Thulasiraman and M. N. S. Swamy Graphs: Theory and Algorithms ISBN: 9781118033104 %CITAVIPICKER£9781118033104£Titel anhand dieser ISBN in Citavi-Projekt übernehmen£% John Wüey & Sons, Inc., 1992

Course L0653: Ergonomics	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Armin Bossemeyer
Language	DE
Cycle	WiSe
Content	
Literature	

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

Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 Minuten
scale	
Lecturer	NN, Dr. Johannes Nicolas Gebhardt
Language	DE
Cycle	SoSe
Content	 Processes and methods of product development - from idea to market launch identification of market and technology potentials development of a common product architecture Synchronized product development across all engineering disciplines product validation incl. customer view Steering and optimization of product development Design of processes for product development IT systems for product development Establishment of management standards Typical types of organization
Literature	 Bender: Embedded Systems - qualitätsorientierte Entwicklung Ehrlenspiel: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit Gausemeier/Ebbesmeyer/Kallmeyer: Produktinnovation - Strategische Planung und Entwicklung der Produkte von morger Haberfellner/de Weck/Fricke/Vössner: Systems Engineering: Grundlagen und Anwendung Lindemann: Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden Pahl/Beitz: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung. Methoden und Anwendung VDI-Richtlinie 2206: Entwicklungsmethodik für mechatronische Systeme

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

Course L2012: Industry 4.0 for engineers	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	120 min
scale	
Lecturer	Prof. Thorsten Schüppstuhl
Language	DE
Cycle	SoSe
Content	
Literature	

Course L0087: Microcontroller Circuits: Implementation in Hardware and Software	
Тур	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and	10 min. Vortrag + anschließende Diskussion
scale	
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe/SoSe
Content	
Literature	ATmega16A 8-bit Microcontroller with 16K Bytes In-System Programmable Flash - DATASHEET, Atmel Corporation 2014
	Atmel AVR 8-bit Instruction Set Instruction Set Manual, Atmel Corporation 2016

Course L0724: Microsystems	Technology
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	
	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOJ, SCREAM process, LGA, SUB, rapid prototypring) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, nj unction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer) Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process) Magnetic Sensors (galvanomagnetic sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, angneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensor: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor; angneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensor: pellistor and thermal conduct
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

ανΤ	Project-/problem-based Learning
Hrs/wk	
CP	
	Independent Study Time 48, Study Time in Lecture 42
	Schriftliche Ausarbeitung
Examination duration and	
scale	
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
114	
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

Тур	Lecture
Hrs/wk	
CP	3
	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur 60 min
scale	
	Dr. Simon Markus Kothe
Language	
Cycle	
-	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufactur
	processes that change the form and physical properties of raw materials. Manufacturing is a central driver of econo development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities resi in enormous global energy and material demands that are harmful to both the environment and people. Historically, indusi activities were mostly oriented towards economic constraints, while social and environmental consequences were only ha considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the nat regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. Thi emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Ear annual regenerative capacity.
	This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cyclo products. For this, the following topics will be highlighted:
	- Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance tomorrow's manufacturing;
	- raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for environmental impact of manufactured products;
	- Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy a resource efficiency;
	- Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps modeling (1), evaluating (2) and improving (3);
	- Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA);
	- Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product cycle assessment.
Literature	Literatur:
	- Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing.
	- Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Ch Springer International Publishing.
	- Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapo Springer.
	- Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer Internatic Publishing.
	- Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG.
	- Vorlesungsskript.

Course L1077: Process Measurement Engineering		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	45 Minuten	
scale		
Lecturer	Prof. Roland Harig	
Language	DE/EN	
Cycle	SoSe	
Content	Process measurement engineering in the context of process control engineering	
	 Challenges of process measurement engineering 	
	 Instrumentation of processes 	
	 Classification of pickups 	
	Systems theory in process measurement engineering	
	 Generic linear description of pickups 	
	 Mathematical description of two-port systems 	
	Fourier and Laplace transformation	
	Correlational measurement	
	Wide band signals	
	 Auto- and cross-correlation function and their applications 	
	 Fault-free operation of correlational methods 	
	Transmission of analog and digital measurement signals	
	 Modulation process (amplitude and frequency modulation) 	
	• Multiplexing	
	 Analog to digital converter 	
Literature	- Färber: "Prozeßrechentechnik", Springer-Verlag 1994	
	- Kiencke, Kronmüller: "Meßtechnik", Springer Verlag Berlin Heidelberg, 1995	
	- A. Ambardar: "Analog and Digital Signal Processing" (1), PWS Publishing Company, 1995, NTC 339	
	- A. Papoulis: "Signal Analysis" (1), McGraw-Hill, 1987, NTC 312 (LB)	
	- M. Schwartz: "Information Transmission, Modulation and Noise" (3,4), McGraw-Hill, 1980, 2402095	
	- S. Haykin: "Communication Systems" (1,3), Wiley&Sons, 1983, 2419072	
	- H. Sheingold: "Analog-Digital Conversion Handbook" (5), Prentice-Hall, 1986, 2440072	
	- J. Fraden: "AIP Handbook of Modern Sensors" (5,6), American Institute of Physics, 1993, MTB 346	

Course L1083: Process Measurement Engineering	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	
scale	
Lecturer	Prof. Roland Harig
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0664: Feedback Control in Medical Technology				
Тур	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Examination Form	Mündliche Prüfung			
Examination duration and	20 min			
scale				
Lecturer	Johannes Kreuzer, Christian Neuhaus			
Language	DE			
Cycle	SoSe			
Content	Always viewed from the engineer's point of view, the lecture is structured as follows: Introduction to the topic Fundamentals of physiological modelling Introduction to Breathing and Ventilation Physiology and Pathology in Cardiology Introduction to the Regulation of Blood Glucose Kidney function and renal replacement therapy Representation of the control technology on the concrete ventilator Excursion to a medical technology company Techniques of modeling, simulation and controller development are discussed. In the models, simple equivalent block diagrams for physiological processes are derived and explained how sensors, controllers and actuators are operated. MATLAB and SIMULINK are used as development tools.			
Literature	 Leonhardt, S., & Walter, M. (2016). Medizintechnische Systeme. Berlin, Heidelberg: Springer Vieweg. Werner, J. (2005). Kooperative und autonome Systeme der Medizintechnik. München: Oldenbourg. Oczenski, W. (2017). Atmen : Atemhilfen ; Atemphysiologie und Beatmungstechnik: Georg Thieme Verlag KG. 			

Course L1630: Applied Dynamics		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 min	
scale		
Lecturer	Prof. Robert Seifried	
Language	DE	
Cycle	SoSe	
Content	 Modelling of Multibody Systems Basics from kinematics and kinetics Constraints Multibody systems in minimal coordinates State space, linearization and modal analysis Multibody systems with kinematic constraints Multibody systems as DAE Non-holonomic multibody systems Experimental Methods in Dynamics 	
Literature	Schiehlen, W.; Eberhard, P.: Technische Dynamik, 4. Auflage, Vieweg+Teubner: Wiesbaden, 2014. Woernle, C.: Mehrkörpersysteme, Springer: Heidelberg, 2011. Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.	

Courses			
Fitle	Тур	Hrs/wk	СР
Applied Automation (L1592)	Project-/problem-based Learning	3	3
Ergonomics (L0653)	Lecture	2	3
Advanced Training Course SE-ZERT	(L2739) Project-/problem-based Learning	2	3
Development Management for Med	hatronics (L1512) Lecture	2	3
atigue & Damage Tolerance (L031	.0) Lecture	2	3
ndustry 4.0 for engineers (L2012)	Lecture	2	3
Aicrocontroller Circuits: Implement	ation in Hardware and Software (L0087) Seminar	2	2
licrosystems Technology (L0724)	Lecture	2	4
Model-Based Systems Engineering	(MBSE) with SysML/UML (L1551) Project-/problem-based Learning	3	3
Sustainable Industrial Production (I	.2863) Lecture	2	3
Process Measurement Engineering	(L1077) Lecture	2	3
Process Measurement Engineering	(L1083) Recitation Section (large)	1	1
eedback Control in Medical Techn	ology (L0664) Lecture	2	3
Applied Dynamics (L1630)	Lecture	2	3
Module Responsible	NN		
Admission Requirements	None		
Recommended Previous	None		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	Students are able to express their extended knowledge and discuss the connection of dil	fferent specia	l fields or applicat
	areas of mechatronics		
	- Chudente are qualified to connect different energial fields with each other		
	 Students are qualified to connect different special fields with each other 		
<i></i>	Students are qualified to connect different special fields with each other		
Skills		areas	
Skills	Students can apply specialized solution strategies and new scientific methods in selected		approaches
Skills			approaches
Skills Personal Competence	Students can apply specialized solution strategies and new scientific methods in selected		a approaches
	 Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can develop 		approaches
Personal Competence	 Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can develop 	p own solutior	approaches
Personal Competence Social Competence Autonomy	 Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can develop None	p own solutior	approaches
Personal Competence Social Competence Autonomy	 Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can develop None Students are able to develop their knowledge and skills by autonomous election of courses 	p own solutior	approaches
Personal Competence Social Competence Autonomy Workload in Hours Credit points	 Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can develop None Students are able to develop their knowledge and skills by autonomous election of courses 	p own solutior	approaches

Course L159	2: Applied Automation
Тур	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in	Independent Study Time 48, Study Time in Lecture 42
Hours	
Examination	Mündliche Prüfung
Form	
Examination	30 Minuten
duration	
and scale	
	Prof. Thorsten Schüppstuhl
Language	
Cycle	WiSe
	-Project Based Learning -Robot Operating System -Robot structure and description -Motion description -Calibration -Accuracy
Literature	John J. Craig Introduction to Robotics - Mechanics and Control ISBN: 0131236296 Pearson Education, Inc., 2005 Stefan Hesse Grundlagen der Handhabungstechnik ISBN: 3446418725 München Hanser, 2010 K. Thulasiraman and M. N. S. Swamy Graphs: Theory and Algorithms ISBN: 9781118033104 %CITAVIPICKER£9781118033104£Titel anhand dieser ISBN in Citavi-Projekt übernehmen£% John Wüey & Sons, Inc., 1992

Course L0653: Ergonomics	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Armin Bossemeyer
Language	DE
Cycle	WiSe
Content	
Literature	

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

Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 Minuten
scale	
Lecturer	NN, Dr. Johannes Nicolas Gebhardt
Language	DE
Cycle	SoSe
Content	 Processes and methods of product development - from idea to market launch identification of market and technology potentials development of a common product architecture Synchronized product development across all engineering disciplines product validation incl. customer view Steering and optimization of product development Design of processes for product development IT systems for product development Establishment of management standards Typical types of organization
Literature	 Bender: Embedded Systems - qualitätsorientierte Entwicklung Ehrlenspiel: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit Gausemeier/Ebbesmeyer/Kallmeyer: Produktinnovation - Strategische Planung und Entwicklung der Produkte von morger Haberfellner/de Weck/Fricke/Vössner: Systems Engineering: Grundlagen und Anwendung Lindemann: Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden Pahl/Beitz: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung. Methoden und Anwendung VDI-Richtlinie 2206: Entwicklungsmethodik für mechatronische Systeme

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

Course L2012: Industry 4.0 for engineers	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	120 min
scale	
Lecturer	Prof. Thorsten Schüppstuhl
Language	DE
Cycle	SoSe
Content	
Literature	

Course L0087: Microcontroller Circuits: Implementation in Hardware and Software	
Тур	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and	10 min. Vortrag + anschließende Diskussion
scale	
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe/SoSe
Content	
Literature	ATmega16A 8-bit Microcontroller with 16K Bytes In-System Programmable Flash - DATASHEET, Atmel Corporation 2014
	Atmel AVR 8-bit Instruction Set Instruction Set Manual, Atmel Corporation 2016

Course L0724: Microsystems	Technology
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer) Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensor; organic semiconductor gas sensor; pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor; pielistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor; pielistor and thermal conductivity sensor; metal oxide semiconductor gas senso
	 chip, microanalytics) MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration) Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002 N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009 T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010 G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

Тур	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung
Examination duration and	ca. 10 Seiten
scale	
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 language
	SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Base
	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
Literature	- Skipt zur Vollesung - Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008
	- Weintens, T.: Systems Engineering mit Sysmi, one. Modellering, Analyse, Design. 2. Aurage, dpunkt. verag, 2008 - Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011
	- noit, J., reny, S.A., brownsword, M.: Model-based Requirements Engineering. Institution Engineering & Tech, 2011

Тур	Lecture
Hrs/wk	
	3
_	
	Independent Study Time 62, Study Time in Lecture 28
	Klausur
xamination duration and scale	60 min
	Dr. Gimen Merluye Kekke
	Dr. Simon Markus Kothe
Language	
Cycle	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufactu
	 Industrial production decids with the infinitiate of physical products to statisty number needs daing values infinitiated processes that change the form and physical properties of raw materials. Manufacturing is a central driver of econo development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities resine normous global energy and material demands that are harmful to both the environment and people. Historically, indus activities were mostly oriented towards economic constraints, while social and environmental consequences were only had considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the nat regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. This emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Ear annual regenerative capacity. This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cycli products. For this, the following topics will be highlighted: Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance tomorrow's manufacturing; raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for environmental impact of manufactured products; Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy resource efficiency; Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps modeling (1), evaluating (2) and improving (3); Resource efficiency of industrial manufacturing v
Literature	Literatur:
	- Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing.
	- Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Ch Springer International Publishing.
	- Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapo Springer.
	- Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer Internatio Publishing.
	- Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG.

Course L1077: Process Meas	urement Engineering
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	45 Minuten
scale	
Lecturer	Prof. Roland Harig
Language	DE/EN
Cycle	SoSe
Content	 Process measurement engineering in the context of process control engineering Challenges of process measurement engineering Instrumentation of processes Classification of pickups Systems theory in process measurement engineering Generic linear description of pickups Mathematical description of two-port systems Fourier and Laplace transformation Correlational measurement Wide band signals
	 Auto- and cross-correlation function and their applications Fault-free operation of correlational methods Transmission of analog and digital measurement signals Modulation process (amplitude and frequency modulation) Multiplexing Analog to digital converter
Literature	 Färber: "Prozeßrechentechnik", Springer-Verlag 1994 Kiencke, Kronmüller: "Meßtechnik", Springer Verlag Berlin Heidelberg, 1995 A. Ambardar: "Analog and Digital Signal Processing" (1), PWS Publishing Company, 1995, NTC 339 A. Papoulis: "Signal Analysis" (1), McGraw-Hill, 1987, NTC 312 (LB)
	 - M. Schwartz: "Information Transmission, Modulation and Noise" (3,4), McGraw-Hill, 1980, 2402095 - S. Haykin: "Communication Systems" (1,3), Wiley&Sons, 1983, 2419072 - H. Sheingold: "Analog-Digital Conversion Handbook" (5), Prentice-Hall, 1986, 2440072 - J. Fraden: "AIP Handbook of Modern Sensors" (5,6), American Institute of Physics, 1993, MTB 346

Course L1083: Process Measurement Engineering	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	
scale	
Lecturer	Prof. Roland Harig
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0664: Feedback Con	trol in Medical Technology		
Тур	ecture		
Hrs/wk			
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Mündliche Prüfung		
Examination duration and	20 min		
scale			
Lecturer	Johannes Kreuzer, Christian Neuhaus		
Language	DE		
Cycle	SoSe		
Content	Always viewed from the engineer's point of view, the lecture is structured as follows: Introduction to the topic Fundamentals of physiological modelling Introduction to Breathing and Ventilation Physiology and Pathology in Cardiology Introduction to the Regulation of Blood Glucose Kidney function and renal replacement therapy Representation of the control technology on the concrete ventilator Excursion to a medical technology company Techniques of modeling, simulation and controller development are discussed. In the models, simple equivalent block diagrams for physiological processes are derived and explained how sensors, controllers and actuators are operated. MATLAB and SIMULINK are used as development tools.		
Literature	 Leonhardt, S., & Walter, M. (2016). Medizintechnische Systeme. Berlin, Heidelberg: Springer Vieweg. Werner, J. (2005). Kooperative und autonome Systeme der Medizintechnik. München: Oldenbourg. Oczenski, W. (2017). Atmen : Atemhilfen ; Atemphysiologie und Beatmungstechnik: Georg Thieme Verlag KG. 		

Course L1630: Applied Dyna	mics		
Тур	Lecture		
Hrs/wk			
CP			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 min		
scale			
Lecturer	Prof. Robert Seifried		
Language	DE		
Cycle	SoSe		
Content	 Modelling of Multibody Systems Basics from kinematics and kinetics Constraints Multibody systems in minimal coordinates State space, linearization and modal analysis Multibody systems with kinematic constraints Multibody systems as DAE Non-holonomic multibody systems Experimental Methods in Dynamics 		
Literature	Schiehlen, W.; Eberhard, P.: Technische Dynamik, 4. Auflage, Vieweg+Teubner: Wiesbaden, 2014. Woernle, C.: Mehrkörpersysteme, Springer: Heidelberg, 2011. Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.		

Courses			
Title Applied Humanoid Robotics (L1794	Typ Hrs/wk CP) Project-/problem-based Learning 6 6		
Module Responsible	Patrick Göttsch		
Admission Requirements	None		
Recommended Previous Knowledge	 Object oriented programming; algorithms and data structures Introduction to control systems Control systems theory and design Mechanics 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	 Students can explain humanoid robots. Students can explain the basic concepts, relationships and methods of forward- and 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 other tasks. They are capable of using models in Matlab for simulation and testing these models if necessary with C++ code on the re robot system. They are capable of selecting methods for solving abstract problems, for which no standard methods are available, an apply it successfully. 		
Personal Competence Social Competence	 Students can develop joint solutions in mixed teams and present these. They can provide appropriate feedback to others, and constructively handle feedback on their own results 		
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 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 II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory		

Course L1794: Applied Humanoid Robotics			
Тур	Project-/problem-based Learning		
Hrs/wk			
CP	6		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Lecturer	Patrick Göttsch		
Language	DE/EN		
Cycle	WiSe/SoSe		
Content			
Literature	B. Siciliano, O. Khatib. "Handbook of Robotics. Part A: Robotics Foundations", Springer (2008)		

Module M1269: Lab C	yber-Physical Systems				
Courses					
Title Lab Cyber-Physical Systems (L1740	Typ Hrs/wk CP D) Project-/problem-based Learning 4 6				
Module Responsible	Prof. Heiko Falk				
Admission Requirements	None				
Recommended Previous	Module "Embedded Systems"				
Knowledge					
	After taking part successfully, students have reached the following learning results				
Professional Competence					
	Cyber-Physical Systems (CPS) are tightly integrated with their surrounding environment, via sensors, A/D and D/A converters,				
Knowledge	actors. Due to their particular application areas, highly specialized sensors, processors and actors are common. Accordingly, th				
	is a large variety of different specification approaches for CPS - in contrast to classical software engineering approaches.				
	is a large valiety of university specification approaches for CFS - in contrast to classical software engineering approaches.				
	Based on practical experiments using robot kits and computers, the basics of specification and modelling of CPS are taught.				
	lab introduces into the area (basic notions, characteristical properties) and their specification techniques (models of computat				
	hierarchical automata, data flow models, petri nets, imperative approaches). Since CPS frequently perform control tasks, the lab				
	experiments will base on simple control applications. The experiments will use state-of-the-art industrial specification tool				
	(MATLAB/Simulink, LabVIEW, NXC) in order to model cyber-physical models that interact with the environment via sensors a				
	actors.				
Skills	After successful attendance of the lab, students are able to develop simple CPS. They understand the interdependencies betwee				
	CPS and its surrounding processes which stem from the fact that a CPS interacts with the environment via sensors, A/D convert				
	digital processors, D/A converters and actors. The lab enables students to compare modelling approaches, to evaluate the				
	advantages and limitations, and to decide which technique to use for a concrete task. They will be able to apply these technique				
	to practical problems. They obtain first experiences in hardware-related software development, in industry-relevant specifica				
	tools and in the area of simple control applications.				
Personal Competence					
Social Competence	Students are able to solve similar problems alone or in a group and to present the results accordingly.				
Autonomy	Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written elaboration				
Examination duration and	Execution and documentation of all lab experiments				
scale					
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory				
Following Curricula	Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory				
	Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Computer Science: Elective Compulsory				
	Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory				
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory				
	Mechatronics: Specialisation System Design: Elective Compulsory				
	Mechatronics: Technical Complementary Course: Elective Compulsory				

Course L1740: Lab Cyber-Phy	Course L1740: Lab Cyber-Physical Systems		
Тур	Project-/problem-based Learning		
Hrs/wk	4		
CP	6		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Lecturer	Prof. Heiko Falk		
Language	DE/EN		
Cycle	SoSe		
Content	 Experiment 1: Programming in NXC Experiment 2: Programming the Robot in Matlab/Simulink Experiment 3: Programming the Robot in LabVIEW 		
Literature	 Peter Marwedel. Embedded System Design - Embedded System Foundations of Cyber-Physical Systems. 2 nd Edition, Springer, 2012. Begleitende Foliensätze 		

Module M1306: Contr	ol Lab C			
Courses				
Title		Тур	Hrs/wk	СР
Control Lab IX (L1836)		Practical Course	1	1
Control Lab VII (L1834)		Practical Course	1	1
Control Lab VIII (L1835)		Practical Course	1	1
Admission Requirements	None			
Recommended Previous	. State and a mathada			
Knowledge	State space methods			
	LQG control			
	 H2 and H-infinity optimal control 			
	 uncertain plant models and robu 	ust control		
	LPV control			
Educational Objectives	After taking part successfully, students	s have reached the following learning results		
Professional Competence				
Knowledge				
Kilowicage	 Students can explain the difference 	nce between validation of a control lop in simulati	on and experimental v	validation
Skills				
SKIIIS	 Students are capable of apply 	ing basic system identification tools (Matlab System)	stem Identification To	olbox) to identif
	dynamic model that can be used	d for controller synthesis		
	 They are capable of using star 	ndard software tools (Matlab Control Toolbox) fo	r the design and imp	elementation of L
	controllers			
	 They are capable of using stand 	lard software tools (Matlab Robust Control Toolbox) for the mixed-sensi	tivity design and
	implementation of H-infinity opt	imal controllers		
		g model uncertainty, and of designing and implem	enting a robust contro	oller
		ard software tools (Matlab Robust Control Toolbox)	-	
	LPV gain-scheduled controllers		···· ··· ···· ····· ·····	
Personal Competence				
Social Competence	Chudanta ann uadh in taona ta			
	 Students can work in teams to c 	conduct experiments and document the results		
Autonomy				
	 Students can independently car 	ry out simulation studies to design and validate co	ntrol loops	
Workload in Hours	Independent Study Time 48, Study Tim	ne in Lecture 42		
Credit points	3			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	1			
scale				
Assignment for the	Electrical Engineering: Specialisation C	Control and Power Systems Engineering: Elective C	ompulsory	
Following Curricula		t Systems and Robotics: Elective Compulsory	-	
	Mechatronics: Specialisation System D			
		ore Qualification: Elective Compulsory		

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

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

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

Courses				
Title		Тур	Hrs/wk	СР
Advanced Topics in Vibration (L174	3)	Project-/problem-based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Vibration Theory			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follo	wing learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts of Advance	d Vibrations and to develop and resea	rch new terms	and concepts.
Skills	Students are able to apply existing methods and procesures of Adva	anced Vibrations and to develop novel	methods and p	rocedures.
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks individually and	to identify and follow up novel resear	ch tasks by the	mselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Mechatronics: Specialisation System Design: Elective Compuls	ory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics:	Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective Com	pulsory		
	Theoretical Mechanical Engineering: Specialisation Product De	velopment and Production: Elective	o Compulsory	

Course L1/43: Advanced Topics in Vibration			
Тур	oject-/problem-based Learning		
Hrs/wk			
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	esearch Topics in Vibrations.		
Literature	Aktuelle Veröffentlichungen		

Courses				
Title		Тур	Hrs/wk	СР
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge	 Introduction to control systems 			
	Introduction to control systemsControl theory and design			
	• Control theory and design			
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Knowledge	 Students can explain humanoid ro 	bots		
	•	rol concepts for different tasks in humanoid ro	obotics	
			550000	
Skills	 Students acquire knowledge about 	t selected aspects of humanoid robotics, base	d on specified literature	
	, .	sults and present them to the participants		
	 Students practice to prepare and g 	give a presentation		
Personal Competence				
Social Competence	Students are capable of developin	g solutions in interdisciplinary teams and pres	sent them	
	They are able to provide appropria	ate feedback and handle constructive criticism	n of their own results	
A				
Autonomy	 Students evaluate advantages ar 	nd drawbacks of different forms of presenta	ation for specific tasks	and select the be
	solution			
	 Students familiarize themselves v 	with a scientific field, are able of introduce it	and follow presentatio	ns of other studen
	such that a scientific discussion de	evelops		
Workload in Hours	Independent Study Time 32, Study Time	in Lecture 28		
Credit points	2			
Course achievement				
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Mechatronics: Specialisation Intelligent S	systems and Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Des	ign: Elective Compulsory		
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation In	nplants and Endoprostheses: Elective Compul	sory	
	Biomedical Engineering: Specialisation M	ledical Technology and Control Theory: Elective	e Compulsory	
	Biomedical Engineering: Specialisation M	lanagement and Business Administration: Elec	ctive Compulsory	
	Theoretical Mechanical Engineering: Spe	cialisation Robotics and Computer Science: El	ective Compulsory	

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

Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Ident	ification (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Classical control (frequency response)	onse, root locus)		
	State space methods			
	Discrete-time systems			
	Linear algebra, singular value dec Resis knowledge about stochastic			
	 Basic knowledge about stochastic 	processes		
Educational Objectives	After taking part successfully, students I	have reached the following learning results		
Professional Competence				
Knowledge	• Chudente con evolein the concer	I framework of the prediction owner pathod	and its application to a	veriety of linear s
	 Students can explain the general nonlinear model structures 	I framework of the prediction error method a	and its application to a	variety of liftear a
		perceptron networks are used to model nonlin	oar dynamics	
		mate predictive control scheme can be based	-	le.
		pace identification and its relation to Kalman		.15
	• They can explain the loca of subs		callsation theory	
Skills	• Students are capable of applyin	a the predicition error method to the evneri	montal identification of	linear and poplin
	models for dynamic systems	g the predicition error method to the experi		
		g a nonlinear predictive control scheme based	on a neural notwork me	dol
		space algorithms to the experimental identific		
		idard software tools (including the Matlab Syst		
	• They can do the above using star	including the Matlab Syst		(^)
Personal Competence				
Social Competence	Students can work in mixed groups on s	pecific problems to arrive at joint solutions.		
Autonomy	Students are able to find required inform	nation in sources provided (lecture notes, liter	ature software docume	ntation) and use it
hateheny	solve given problems.			
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Co	ntrol and Power Systems Engineering: Elective	e Compulsory	
Following Curricula		Systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System De			
		Artificial Organs and Regenerative Medicine: El		
		mplants and Endoprostheses: Elective Comput	-	
		Aedical Technology and Control Theory: Comp	-	
		Ianagement and Business Administration: Elec	ctive Compulsory	
	Theoretical Mechanical Engineering: Cor	e Qualification: Elective Compulsory		

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

Module M0939: Contr	ol Lab A			
Courses				
Title Control Lab I (L1093)		Typ Practical Course	Hrs/wk	СР 1
Control Lab I (L1291)		Practical Course	1	1
Control Lab III (L1665)		Practical Course	1	1
Control Lab IV (L1666)		Practical Course	1	1
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	 State space methods 			
	LQG control			
	 H2 and H-infinity optimal control 			
	 uncertain plant models and robust control 			
	LPV control			
Educational Objectives	After taking part successfully, students have read	ched the following learning results		
Professional Competence				
Knowledge				
	 Students can explain the difference between the students of the s	en validation of a control lop in simulation	n and experimental v	alidation
Skills				
	 Students are capable of applying basic 	system identification tools (Matlab Syst	em Identification To	olbox) to identify
	dynamic model that can be used for contro	oller synthesis		
	They are capable of using standard soft	ware tools (Matlab Control Toolbox) for	the design and imp	lementation of LQC
	controllers			
	 They are capable of using standard software 	are tools (Matlab Robust Control Toolbox)	for the mixed-sensit	ivity design and the
	implementation of H-infinity optimal control	ollers		
	They are capable of representing model un	ncertainty, and of designing and impleme	enting a robust contro	oller
	 They are capable of using standard softwa 	re tools (Matlab Robust Control Toolbox)	for the design and th	e implementation o
	LPV gain-scheduled controllers			
D				
Personal Competence				
Social Competence	 Students can work in teams to conduct explanation 	periments and document the results		
Autonomy	 Students can independently carry out simulation 	ulation studies to design and validate con	trol loops	
	· · · · · · · · · · · · · · · · · · ·	, , , , , , , , , , , , , , , , , , ,		
Workload in Hours		re 56		
Credit points				
Course achievement	None			
Examination	Written elaboration			
Examination duration and	1			
scale	Flashring Engineering, Chapielingting, Control and	Device Cycleme Engineering, Elective Co		
	Electrical Engineering: Specialisation Control and		mpulsory	
Following Curricula	Mechatronics: Specialisation System Design: Elec			
	Mechatronics: Specialisation Intelligent Systems			
	Theoretical Mechanical Engineering: Specialisation	on Robotics and Computer Science: Electi	ve Compulsory	
	1			

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, Adwait Datar, Patrick Göttsch
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

Module Manual M.Sc. "Mechatronics"

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

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

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

Module M0924: Softw	are for Embedded Systems			
Module Mosz4. Soltw	are for Embedded Systems			
Courses				
Title		Тур	Hrs/wk	СР
Software for Embdedded Systems ((L1069)	Lecture	2	3
Software for Embdedded Systems ((L1070)	Recitation Section (s	mall) 3	3
Module Responsible	Prof. Bernd-Christian Renner			
Admission Requirements	None			
Recommended Previous	. Cool la sudadas en dour origanos i			
Knowledge	Good knowledge and experience i			
	Basis knowledge in software engir	5		
	 Basic understanding of assembly I 	anguage		
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Knowledge	Students know the basic principles and procedures of software engineering for embedded systems. They are able to describe the			
	usage and pros of event based programming using interrupts. They know the components and functions of a concret			
	microcontroller. The participants explain requirements of real time systems. They know at least three scheduling algorithms for			
	real time operating systems including the	eir pros and cons.		
Skills	Its and the problem of the proble			scheduler. They u
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 110, Study Time	e in Lecture 70		
Credit points	6			
Course achievement	Compulsory Bonus Form	Description		
	No 10 % Attestation			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Computer Science: Specialisation I. Com	puter and Software Engineering: Elective Co	mpulsory	
Following Curricula	Electrical Engineering: Specialisation Info	ormation and Communication Systems: Elec	tive Compulsory	
	Information and Communication Systems	s: Specialisation Communication Systems, F	ocus Software: Elective C	ompulsory
	Mechatronics: Technical Complementary	Course: Elective Compulsory		
	Mechatronics: Specialisation Intelligent S	systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Des			
	· · ·	ialisation Embedded Systems: Elective Com	pulsory	

Course L1069: Software for B	Embdedded Systems
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bernd-Christian Renner
Language	DE/EN
Cycle	SoSe
Content	 General-Purpose Processors Programming the Atmel AVR Interrupts C for Embedded Systems Standard Single Purpose Processors: Peripherals Finite-State Machines Memory Operating Systems for Embedded Systems Real-Time Embedded Systems Boot loader and Power Management
Literature	 Embedded System Design, F. Vahid and T. Givargis, John Wiley Programming Embedded Systems: With C and Gnu Development Tools, M. Barr and A. Massa, O'Reilly C und C++ für Embedded Systems, F. Bollow, M. Homann, K. Köhn, MITP The Art of Designing Embedded Systems, J. Ganssle, Newnses Mikrocomputertechnik mit Controllern der Atmel AVR-RISC-Familie, G. Schmitt, Oldenbourg Making Embedded Systems: Design Patterns for Great Software, E. White, O'Reilly

Course L1070: Software for I	ourse L1070: Software for Embdedded Systems		
Тур	Recitation Section (small)		
Hrs/wk	3		
CP	3		
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42		
Lecturer	Prof. Bernd-Christian Renner		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses Title Compilers for Embedded Systems (L1692) Compilers for Embedded Systems (L1693) Module Responsible Prof. Heiko Falk Admission Requirements None Recommended Previous Module "Embedded Systems" Knowledge C/C++ Programming skills Educational Objectives After taking part successfully, students have reached the follow Professional Competence Educational Competence		Hrs/wk 3 1	CP 4 2		
Compilers for Embedded Systems (L1692) Compilers for Embedded Systems (L1693) Module Responsible Prof. Heiko Falk Admission Requirements None Recommended Previous Knowledge C/C++ Programming skills Educational Objectives After taking part successfully, students have reached the follow	Lecture Project-/problem-based Learning	3	4		
Module Responsible Prof. Heiko Falk Admission Requirements None Recommended Previous Module "Embedded Systems" Knowledge C/C++ Programming skills Educational Objectives After taking part successfully, students have reached the follow	ving learning results	1	2		
Admission Requirements None Recommended Previous Module "Embedded Systems" Knowledge C/C++ Programming skills Educational Objectives After taking part successfully, students have reached the follow					
Recommended Previous Module "Embedded Systems" Knowledge C/C++ Programming skills Educational Objectives After taking part successfully, students have reached the follow					
Knowledge C/C++ Programming skills Educational Objectives After taking part successfully, students have reached the follow					
C/C++ Programming skills Educational Objectives After taking part successfully, students have reached the follow					
Professional Competence	ear. Within such systems, the amo				
	ear. Within such systems, the amo				
 embedded processors grows continuously due to its lower coss of embedded systems, highly optimized and application-spe impose high demands on compilers which have to generate cost the students are able to illustrate the structure and organization of such comp to distinguish and explain intermediate representations is to assess optimizations and their underlying problems in The high demands on compilers for embedded systems mal particular, which kinds of optimizations are applicable at the source how the translation from source code to assembly code i which kinds of optimizations are applicable at the assem how register allocation is performed, and how memory hierarchies can be exploited effectively. 	 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 lear particular, which kinds of optimizations are applicable at the source code level, how the translation from source code to assembly code is performed, which kinds of optimizations are applicable at the assembly code level, how register allocation is performed, and how memory hierarchies can be exploited effectively. 				
energy dissipation, code size), the students learn to evaluate the skills After successful completion of the course, students shall be ab be enabled to assess which kind of code optimization should be assembly code) within a compiler. While attending the labs, the students will learn to implement a	le to translate high-level program e applied most effectively at whic	code into mac h abstraction l	hine code. They v evel (e.g., source		
Personal Competence					
Social Competence Students are able to solve similar problems alone or in a group	and to present the results accord	ingly.			
Autonomy Students are able to acquire new knowledge from specific literation			classes.		
Workload in Hours Independent Study Time 124, Study Time in Lecture 56					
Credit points 6					
Course achievement None					
Examination Oral exam					
Examination duration and 30 min					
scale					
Assignment for the Computer Science: Specialisation I. Computer and Software Englished	gineering: Elective Compulsory				
Following Curricula Electrical Engineering: Specialisation Information and Commun	ication Systems: Elective Compuls	sory			
Aircraft Systems Engineering: Core Qualification: Elective Comp	oulsory				
Mechatronics: Specialisation Intelligent Systems and Robotics:					
Mechatronics: Specialisation System Design: Elective Compulso					
Mechatronics: Technical Complementary Course: Elective Comp Theoretical Mechanical Engineering: Specialisation Robotics an	-				

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

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

Module M0630: Robot	ics and Naviga	tion in Medio	cine					
Courses								
Title				Тур	Hrs/wk	СР		
Robotics and Navigation in Medicin	e (L0335)			Lecture	2	3		
Robotics and Navigation in Medicine (L0338) Project Seminar 2 2						2		
Robotics and Navigation in Medicin	Navigation in Medicine (L0336)Recitation Section (small)11							
Module Responsible	Prof. Alexander Schla	efer						
Admission Requirements	None	None						
Recommended Previous	e principles of m	ath (algobra anglu						
Knowledge		ath (algebra, analy						
	 principles of pr solid R or Matla 	ogramming, e.g., i	n Java or C++					
		ad Skills						
Educational Objectives	After taking part succ	essfully, students l	have reached the follow	ving learning results				
Professional Competence								
Knowledge	The students can ex	plain kinematics a	nd tracking systems i	n clinical contexts and illustra	ate systems and	their components in		
	detail. Systems can	be evaluated with	respect to collision d	etection and safety and reg	ulations. Student	s can assess typica		
	systems regarding de	sign and limitation	ıs.					
Chille	The students are able	the standard state	line to a standing and the					
SKIIIS	The students are able	to design and eva	luate navigation system	ms and robotic systems for me	edical applications			
Personal Competence								
Social Competence	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work.							
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate							
	manner.							
Workload in Hours	Independent Study Ti	me 110, Study Tim	ie in Lecture 70					
Credit points	6	F	Description.					
Course achievement	Compulsory Bonus Yes 10 %	Form Presentation	Description					
	Yes 10 %	Written elaborati	on					
Examination	Written exam	Whiteh elaborati						
Examination duration and scale	90 minutes							
	Computer Coloneo, C	acialization II. Into	llicence Engineering, F	lastive Compulson				
-	Computer Science: Sp							
Following Curricula			dical Technology: Elec	lectrical Engineering: Elective	Compulsory			
	-					Compulsory		
International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compul 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					Compuisory			
	-			d Control Theory: Elective Com	pulsory			
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory							
	Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory							
				Production: Elective Compuls				
				Materials: Elective Compulsor	-			
				dical Technology: Elective Cor	-			
	I				-			

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	urse L0338: Robotics and Navigation in Medicine					
Тур	Project Seminar					
Hrs/wk	2					
СР	2					
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28					
Lecturer	Prof. Alexander Schlaefer					
Language	EN					
Cycle	SoSe					
Content	See interlocking course					
Literature	See interlocking course					
Course L0336: Robotics and	urse L0336: Robotics and Navigation in Medicine					
Тур	Recitation Section (small)					
Hrs/wk	1					

111 <i>3</i> / WR	±				
СР					
Workload in Hours	endent Study Time 16, Study Time in Lecture 14				
Lecturer	Prof. Alexander Schlaefer				
Language	EN				
Cycle	SoSe				
Content	See interlocking course				
Literature	See interlocking course				

Module M0803: Embe	aaea Systems						
Courses							
Title		Тур	Hrs/wk	СР			
Embedded Systems (L0805)		Lecture	3	4			
Embedded Systems (L0806)		Recitation Section (small)	1	2			
Module Responsible							
Admission Requirements							
Recommended Previous Knowledge	Computer Engineering						
-	After taking part successfully, students have re	ached the following learning results					
Professional Competence							
-	Embedded systems can be defined as informat	ion processing systems embedded into enclo	sing products. Th	is course teaches t			
-	foundations of such systems. In particular, it d						
	their specification languages (models of comp		of distributed sy	ystems, task graph			
	specification of real-time applications, translation	ons between different models).					
	Another part covers the hardware of embedded systems: Sonsors, A/D and D/A converters, real-time capable communication						
	hardware, embedded processors, memories, e						
	introduction into real-time operating systems,						
	systems using hardware/software co-design (h efficient realizations, compilers for embedded p		isformations of sp	pecifications, energ			
		Socessors) is covered.					
Skills	After having attended the course, students sh						
	relevant parts of technological competences to use in order to obtain a functional embedded systems. In particular, they shall b able to compare different models of computations and feasible techniques for system-level design. They shall be able to judge i						
			design. They sha	Il be able to judge			
Borconal Compotonco	which areas of embedded system design specif	ic risks exist.					
Personal Competence	Students are able to solve similar problems alo	ne or in a group and to present the results ac	cordinaly				
social competence		the of the group and to present the results de	corungly.				
Autonomy	Students are able to acquire new knowledge fro	om specific literature and to associate this kno	owledge with othe	er classes.			
Workload in Hours	Independent Study Time 124, Study Time in Le	cture 56					
Credit points	6						
Course achievement		Description					
	,	and					
Freminetien	practical work						
	Written exam 90 minutes, contents of course and labs						
scale	so minutes, contents of course and labs						
Assignment for the	General Engineering Science (German program	. 7 semester): Specialisation Computer Science	ce: Compulsory				
-	Computer Science: Specialisation Computer an		, in the second s				
	Computer Science: Specialisation I. Computer a	and Software Engineering: Elective Compulsor	У				
	Electrical Engineering: Core Qualification: Elect	ive Compulsory					
	Engineering Science: Specialisation Mechatroni						
	Aircraft Systems Engineering: Core Qualification						
	General Engineering Science (English program,		ective Compulsory				
	Computational Science and Engineering: Core (Mechatronics: Specialisation System Design: El						
	Mechatronics: Specialisation System Design: El						
	Mechatronics: Core Qualification: Elective Com						
	Microelectronics and Microsystems: Specialisat	ion Embedded Systems: Elective Compulsory					
Course L0805: Embedded Sy							
	Lecture						
Hrs/wk CP							
Workload in Hours		ture 42					
	Prof. Heiko Falk						
Language							

Language	EN
Cycle	SoSe
Content	 Introduction Specifications and Modeling Embedded/Cyber-Physical Systems Hardware System Software Evaluation and Validation Mapping of Applications to Execution Platforms Optimization
Literature	 Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2 nd Edition, Springer, 2012., Springer, 2012.

Course L0806: Embedded Sy	irse L0806: Embedded Systems				
Тур	citation Section (small)				
Hrs/wk	1				
CP	2				
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14				
Lecturer	Prof. Heiko Falk				
Language	EN				
Cycle	SoSe				
Content	See interlocking course				
Literature	See interlocking course				

Courses							
Title					Тур	Hrs/wk	СР
Electro- and Contromechanics (L01	.74)				Lecture	2	2
Electro- and Contromechanics (L13	(00)				Recitation Section (small)	1	2
Mechatronics Laboratory (L0196)	1				Project-/problem-based Learning	2	2
Module Responsible	NN						
Admission Requirements	None						
Recommended Previous	Fundamentals of med	hanics, electrome	echanics	and control theor	ТУ		
Knowledge							
Educational Objectives	After taking part succ	essfully, students	have rea	ached the followi	ng learning results		
Professional Competence							
Knowledge	Students are able to	describe method	ls and ca	Iculations to des	sign, model, simulate and optim	nize mechatro	nic systems and c
-	repeat methods to ve	repeat methods to verify and validate models.					
Skills	kills Students are able to plan and execute mechatronic experiments. Students are able to model mechatronic systems and d				systems and der		
	simulations and optimizations.					-,	
Personal Competence							
Social Competence	Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities and define task w					nd define task witl	
	the team.						
Autonomy	Students are able to solve individually exercises related to this lecture with instructional direction.						
	Studente are able to plan, evecute and summarize a mechatronic eventiment						
	Students are able to plan, execute and summarize a mechatronic experiment.						
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70						
Credit points	6						
Course achievement	Compulsory Bonus	Form		Description			
	Yes None	Subject theor	retical	and			
		practical work					
Examination	Written exam						
Examination duration and	90 min						
scale							
Assignment for the	Mechatronics: Special	lisation Intelligent	Systems	and Robotics: E	lective Compulsory		
	Mechatronics: Specialisation System Design: Elective Compulsory						

Course L0174: Electro- and Contromechanics						
Тур	Lecture					
Hrs/wk	2					
CP	2					
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28					
Lecturer	NN					
Language	EN					
Cycle	SoSe					
Content	Introduction to methodical design of mechatronic systems:					
	 Modelling System identification Simulation Optimization 					
Literature	Denny Miu: Mechatronics, Springer 1992					
	Rolf Isermann: Mechatronic systems : fundamentals, Springer 2003					

Course L1300: Electro- and C	urse L1300: Electro- and Contromechanics	
Тур	Recitation Section (small)	
Hrs/wk	1	
CP	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	NN	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0196: Mechatronics	ourse L0196: Mechatronics Laboratory		
	ject-/problem-based Learning		
Hrs/wk	2		
CP	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	NN		
Language	DE/EN		
Cycle	oSe		
Content	Modeling in MATLAB [®] und Simulink [®]		
	Controller Design (Linear, Nonlinear, Observer)		
	Parameter identification		
	Control of a real system with a realtimeboard and Simulink $^{\textcircled{B}}$ RTW		
Literature	Abhängig vom Versuchsaufbau		
	- Depends on the experiment		

Courses				
Title		Τγρ	Hrs/wk	СР
Machine Learning and Data Mining (L0340)		Lecture	2	4
Machine Learning and Data Mining	(L0510)	Recitation Section (small)	2	2
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Stochastics			
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence	Students can explain the difference betwe	en instance-based and model-based learning ap	proaches and they	can enumerate has
		the two basic approaches, either on the b		
		with uncertainty, students can describe suita		
		s, or structures used in these formalisms can	-	
		h different clustering techniques. They depict h		-
	-	d they can summarize how this influences com		
	reinforcement learning can also be explain	ed by students.		
Chille	Chudant daring darising two a rand in two			
SKIIIS		n, propositional rule sets from simple and stati		
		ey present and apply the basic idea of first-ord		
	-	ning parameters of Bayesian networks and cor re learning. They can contrast kNN classifier:		
	-	on areas and algorithmic properties. Students		
		se techniques. Students compare related mad		
		ation. They can distinguish various ensemble	-	
	different goals of those techniques.		5 1	
Personal Competence				
Social Competence				
Autonomy	Independent Study Time 124, Study Time	in Lestrum FC		
Credit points	Independent Study Time 124, Study Time	III Lecture 56		
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	Computer Science: Specialisation II: Intelli	gence Engineering: Elective Compulsory		
Following Curricula	International Management and Engineerin	g: Specialisation II. Information Technology: Elec	tive Compulsory	
	Mechatronics: Technical Complementary C	ourse: Elective Compulsory		
	Mechatronics: Specialisation System Desig			
	Mechatronics: Specialisation Intelligent Sy			

Тур	Lecture		
Hrs/wk	2		
CP			
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, 1 18-21 		
	 Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press 2012 		

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

Courses					
Title			Turn	Line (usis	СР
Intelligent Systems in Medicine (L0	331)		Typ Lecture	Hrs/wk 2	3
Intelligent Systems in Medicine (L0			Project Seminar	2	2
Intelligent Systems in Medicine (L0			Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schl	laefer			
Admission Requirements	None				
Recommended Previous					
Knowledge		math (algebra, analysis/calculus)		
	 principles of s 				
		programming, Java/C++ and R/I	Matlab		
	 advanced pro 	ogramming skills			
Educational Objectives	After taking part suc	ccessfully, students have reache	ed the following learning results		
Professional Competence					
Knowledge	The students are ab	ble to analyze and solve clinical	treatment planning and decision supp	ort problems using	methods for searc
	optimization, and pl	anning. They are able to explain	n methods for classification and their re	spective advantag	es and disadvantag
	in clinical contexts.	The students can compare diffe	erent methods for representing medical	knowledge. They o	an evaluate metho
	in the context of clin	nical data and explain challeng	ges due to the clinical nature of the dat	a and its acquisition	on and due to priva
	and safety requirem	ients.			
Skille	The students can gi	ive reasons for colocting and a	dapting methods for classification, regr	occion and prodic	tion Thoy can acco
SKIIIS	-	-		ession, and predic	LION. They can asse
	the methods based	on actual patient data and evan	uate the implemented methods.		
Personal Competence					
Social Competence	The students are able to grasp practical tasks in groups, develop solution strategies independently, define work processes ar				
	work on them collaboratively.				
The students can critically reflect on the results of		of other groups, make constructive s	suggestions for in	provement and al	
	incorporate them in	to their own work.			
Autonomy	The students can as	sess their level of knowledge ar	nd document their work results. They ca	n critically evaluat	e the results achiev
	and present them in an appropriate argumentative manner to the other groups.				
		Time 110, Study Time in Lecture	e 70		
Credit points					
Course achievement	Yes 10 %	Form Written elaboration	Description		
	Yes 10 %	Presentation			
Examination	Written exam	riesentation			
Examination duration and					
scale	50 minutes				
Assignment for the	Computer Science: 9	Specialisation II: Intelligence En	nineering: Elective Compulsory		
-		ng: Specialisation Medical Techn			
g earlied	-		utational Methods in Biomedical Imaging	g: Compulsory	
	. ,		d Robotics: Elective Compulsory		
	-		ans and Regenerative Medicine: Electiv	e Compulsory	
	-		d Endoprostheses: Elective Compulsory		
	-		nnology and Control Theory: Elective Co	mpulsory	
	_		t and Business Administration: Elective		
	Theoretical Mechani	ical Engineering: Specialisation	Bio- and Medical Technology: Elective C	ompulsory	

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

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

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

-				
Courses				
Title		Тур	Hrs/wk	СР
Industrial Process Automation (L03 Industrial Process Automation (L03		Lecture Recitation Section (small)	2	3 3
	Prof. Alexander Schlaefer	Reclation Section (Small)	L	5
Admission Requirements				
	mathematics and optimization methods			
	principles of automata			
-	principles of algorithms and data structures			
	programming skills			
Educational Objectives	After taking part successfully, students have re-	ached the following learning results		
Professional Competence	After taking part successfully, students have re-	actied the following learning results		
-	The students can evaluate and assess discrete	event systems. They can evaluate propert	ies of processes and	explain methods
hitemedge	process analysis. The students can compare me			
	They can discuss scheduling methods in the			
	disadvantages of different programming meth	ods. The students can relate process au	tomation to method	Is from robotics a
	sensor systems as well as to recent topics like '	cyberphysical systems' and 'industry 4.0'.		
Skills	The students are able to develop and model p		his involves taking	into account optir
	scheduling, understanding algorithmic complex	ity, and implementation using PLCs.		
Personal Competence				
Social Competence	The students can independently define work pr	ocesses within their groups, distribute task	s within the group a	nd develop soluti
	collaboratively.			
Autonomy	The students are able to assess their level of kr	owledge and to document their work resul	ts adequately.	
Workload in Hours	Independent Study Time 124, Study Time in Le	cture 56		
Credit points				
Course achievement	Compulsory Bonus Form	Description		
	No 10 % Excercises			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
-	Bioprocess Engineering: Specialisation A - Gene		-	
Following Curricula	Chemical and Bioprocess Engineering: Specialis			
	Chemical and Bioprocess Engineering: Specialis Computer Science: Specialisation II: Intelligence		e compuisory	
	Electrical Engineering: Specialisation Control ar		mpulsory	
	Aircraft Systems Engineering: Core Qualification	, , ,		
	International Management and Engineering: Sp	ecialisation II. Mechatronics: Elective Comp	ulsory	
	International Management and Engineering: Sp	ecialisation II. Product Development and Pr	oduction: Elective C	ompulsory
	Mechanical Engineering and Management: Spec	cialisation Mechatronics: Elective Compulso	ory	
	Mechatronics: Specialisation Intelligent Systems			
	Theoretical Mechanical Engineering: Specialisat		ve Compulsory	
	International Management and Engineering: Sp International Management and Engineering: Sp Mechanical Engineering and Management: Spec Mechatronics: Specialisation Intelligent System	ecialisation II. Mechatronics: Elective Comp ecialisation II. Product Development and Pr cialisation Mechatronics: Elective Compulsor s and Robotics: Elective Compulsory ion Robotics and Computer Science: Elective rocess Engineering: Elective Compulsory	oduction: Elective C	ompulsory

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

Course L0345: Industrial Pro	Irse 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		

-				
Courses				
Title		Тур	Hrs/wk	CP
Digital Signal Processing and Digital Filters (L0446) Digital Signal Processing and Digital Filters (L0447)		Lecture Recitation Section (large)	3	4
Module Responsible		Reclation Section (httge/	L	L
Admission Requirements				
Recommended Previous	None			
Knowledge	Mathematics 1-3			
Kilowieuge	 Signals and Systems 			
	 Fundamentals of signal and system 	theory as well as random processes.		
	 Fundamentals of spectral transform 	s (Fourier series, Fourier transform, Laplace tra	nsform)	
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence				
Knowledge	The students know and understand basic	algorithms of digital signal processing. They ar	e familiar with the s	spectral transforms
	discrete-time signals and are able to dea	scribe and analyse signals and systems in tin	ne and image doma	ain. They know bas
	structures of digital filters and can ide	entify and assess important properties inclu	ding stability. The	y are aware of th
	effects caused by quantization of filter c	oefficients and signals. They are familiar with	the basics of adap	tive filters. They c
	perform traditional and parametric method	ds of spectrum estimation, also taking a limited	observation window	into account.
	The students are familiar with the content	s of lecture and tutorials. They can explain and	apply them to new r	robloms
	The statenes are familiar war the contene	on rectare and tatonals. They can explain and		iobients.
Skills	The students are able to apply methods o	f digital signal processing to new problems. Th	ey can choose and	parameterize suitab
		sign adaptive filters according to the minimum		
		. based on the LMS or RLS algorithm. Furth		its are able to app
	methods of spectrum estimation and to ta	ke the effects of a limited observation window i	nto account.	
Personal Competence				
Social Competence	The students can jointly solve specific prol	olems.		
Autonomy	The students are able to acquire releva	ant information from appropriate literature s	ources. They can	control their level
	knowledge during the lecture period by so	lving tutorial problems, software tools, clicker s	ystem.	
Workload in Hours	Independent Study Time 110, Study Time	in Locture 70		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Cont	rol and Power Systems Engineering: Elective Co	mpulsory	
Following Curricula	Computer Science in Engineering: Speciali	sation II. Engineering Science: Elective Compuls	ory	
	Information and Communication Systems:	Specialisation Communication Systems, Focus	Signal Processing: E	lective Compulsory
	Mechanical Engineering and Management	Specialisation Mechatronics: Elective Compulse	ory	
	Mechatronics: Specialisation Intelligent Sy	stems and Robotics: Elective Compulsory		
	Microelectronics and Microsystems: Specia	alisation Communication and Signal Processing:	Elective Compulsor	ý
	Theoretical Mechanical Engineering: Speci	alisation Robotics and Computer Science: Electi		

Course L0446: Digital Signal	Processing and Digital Filters
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	
	Prof. Gerhard Bauch
Language	
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
	Traditional and parametric methods of spectrum estimation
Literature	KD. Kammeyer, K. Kroschel: Digitale Signalverarbeitung. Vieweg Teubner.
	V. Oppenheim, R. W. Schafer, J. R. Buck: Zeitdiskrete Signalverarbeitung. Pearson StudiumA. V.
	W. Hess: Digitale Filter. Teubner.
	Oppenheim, R. W. Schafer: Digital signal processing. Prentice Hall.
	S. Haykin: Adaptive flter theory.
	L. B. Jackson: Digital filters and signal processing. Kluwer.
	T.W. Parks, C.S. Burrus: Digital filter design. Wiley.

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

Courses				
Title	Tue			CD
Advanced Topics in Control (L0661) Lect		Hrs/wk	CP 3
Advanced Topics in Control (L0662		itation Section (small)	2	3
Module Responsible				
Admission Requirements				
	H-infinity optimal control, mixed-sensitivity design, linear matrix ineq	ualities		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following le	arning results		
Professional Competence				
Knowledge Skills	 Students can explain the advantages and shortcomings of the They can explain the representation of nonlinear systems in th They can explain how stability and performance conditions for They can explain how gridding techniques can be used to solve They are familiar with polytopic and LFT representations of associated with each of these model structures Students can explain how graph theoretic concepts are us systems They can explain the convergence properties of first order con They can explain analysis and synthesis conditions for formatic Students can explain concepts behind linear and qLPV Model P 	e form of quasi-LPV syst LPV systems can be form e analysis and synthesis f LPV systems and som ed to represent the cor sensus protocols on control loops involving tredictive Control (MPC) nd carry out a mixed-so v models solbox) for these tasks	ems nulated as LMI co problems for LPV e of the basic s mmunication top g either LTI or LPV sensitivity design	systems ynthesis techniqu ology of multiage / agent models
Personal Competence	 tools provided Students can design MPC controllers for linear and non-linear s 	systems using Matlab too	ls	
	Students can work in small groups and arrive at joint results.			
	Students can find required information in sources provided (lecture given problems.	notes, literature, softwar	e documentation) and use it to sol
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Control and Power Systems Eng	ineering: Elective Compu	ulsory	
Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Compulsory	1		
	International Management and Engineering: Specialisation II. Mechati	ronics: Elective Compulse	ory	
	Mechatronics: Specialisation System Design: Elective Compulsory			
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective	e Compulsory		
	Biomedical Engineering: Specialisation Implants and Endoprostheses:	Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and Contr	ol Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management and Business Ad			
	Biomedical Engineering: Specialisation Artificial Organs and Regenera			
	Theoretical Mechanical Engineering: Specialisation Robotics and Com	puter Science: Elective C	Compulsory	

e L0661: Advanced Topics in Control	
	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	Linear Parameter-Varying (LPV) Gain Scheduling
	- Linearizing gain scheduling, hidden coupling
	- Jacobian linearization vs. quasi-LPV models
	- Stability and induced L2 norm of LPV systems
	- Synthesis of LPV controllers based on the two-sided projection lemma
	- Simplifications: controller synthesis for polytopic and LFT models
	- Experimental identification of LPV models
	- Controller synthesis based on input/output models
	- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator
	Control of Multi-Agent Systems
	- Communication graphs
	- Spectral properties of the graph Laplacian
	- First and second order consensus protocols
	- Formation control, stability and performance
	- LPV models for agents subject to nonholonomic constraints
	- Application: formation control for a team of quadrotor helicopters
	Linear and Nonlinear Model Predictive Control based on LMIs
Literature	Werner, H., Lecture Notes "Advanced Topics in Control"
	Selection of relevant research papers made available as pdf documents via StudIP

ourse L0662: Advanced Topics in Control	
Тур	Recitation Section (small)
Hrs/wk	2
CP	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 M1173: Appli				
Courses				
Title	Тур		Hrs/wk	СР
Applied Statistics (L1584)	Lectu	ire	2	3
Applied Statistics (L1586)		ct-/problem-based Learning	2	2
Applied Statistics (L1585)		ation Section (small)	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of statistical methods			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following lea	arning results		
Professional Competence				
Knowledge	Students can explain the statistical methods and the conditions of the	ir use.		
	Students are able to use the statistics program to solve statistics prob	lems and to interpret and d	epict the resul	ts
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 Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes, 28 questions			
scale				
Assignment for the	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory			
Following Curricula	Mechatronics: Specialisation System Design: Elective Compulsory			
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective	e Compulsory		
	Biomedical Engineering: Core Qualification: Compulsory			
	Product Development, Materials and Production: Core Qualification: Ele			
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Te	echnology: Elective Compuls	sory	
• · · · · · · · · · · · · · · · · · · ·				
Course L1584: Applied Statis				
Тур	Lecture			
Hrs/wk				
CP				
	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Michael Morlock			
Language				
Cycle	WiSe			
Content	The goal is to introduce students to the basic statistical methods and t	their application to simple p	roblems. The t	opics 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			

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

Chossing the appropriate statistical method

.

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

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

C						
Courses						
Title Elevible Multibedy Systems (11633	N	Typ Lecture	Hrs/wk	СР 3		
Flexible Multibody Systems (L1632 Optimization of dynamical systems		Lecture	2	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, students have	e reached the following learning results				
Professional Competence						
Knowledge	Students demonstrate basic knowledge an	nd understanding of modeling, simulatio	n and analysis of compl	ex rigid and flexib		
	multibody systems and methods for optimiz	ing dynamic systems after successful cor	npletion of the module.			
Skills	Students are able					
	+ to think holistically					
	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibod					
	systems					
	+ to describe dynamics problems mathematically					
	+ to optimize dynamics problems					
Personal Competence						
	Students are able to					
	+ solve problems in heterogeneous groups	and to document the corresponding resul	ts.			
Autonomy	Students are able to					
	+ assess their knowledge by means of exer	cises.				
	+ acquaint themselves with the necessary I	knowledge to solve research oriented task	s.			
		2				
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56				
Credit points	6					
Course achievement	None					
Examination	Oral exam					
Examination duration and	30 min					
scale						
5	Energy Systems: Core Qualification: Elective					
Following Curricula						
	Mechatronics: Specialisation System Design					
	Mechatronics: Specialisation Intelligent Syst					
	Product Development, Materials and Product		ory			
	Theoretical Mechanical Engineering: Core Q	ualification: Elective Compulsory				

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

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

Module M1229: Contr	ol Lab B					
-						
Courses						
Title		Тур	Hrs/wk	СР		
Control Lab V (L1667)		Practical Course Practical Course	1	1		
Control Lab VI (L1668)		Practical Course	I	1		
Module Responsible						
Admission Requirements	None					
Recommended Previous	State space methods					
Knowledge	LOG control					
	H2 and H-infinity optimal control					
	 uncertain plant models and robust 	t control				
	LPV control					
	After taking part successfully, students h	nave reached the following learning results				
Professional Competence						
Knowledge	 Students can explain the difference 	ce between validation of a control lop in simulation	on and experimental v	alidation		
			and experimental t	anducion		
Skills	 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identification 					
	dynamic model that can be used for controller synthesis					
		lard software tools (Matlab Control Toolbox) for	r the design and imr	ementation of L		
	controllers		the design and mp			
		rd software tools (Matlab Robust Control Toolbox	() for the mixed-sensi	tivity design and t		
	implementation of H-infinity optim		,			
		model uncertainty, and of designing and implem	enting a robust contr	oller		
		rd software tools (Matlab Robust Control Toolbox)	-			
	LPV gain-scheduled controllers		5			
	-					
Personal Competence						
Social Competence	 Students can work in teams to cor 	nduct experiments and document the results				
		• • • • • • • • • • • • • • • • • • • •				
Autonomy	 Students can independently carry 	out simulation studies to design and validate co	ntrol loops			
			11101100005			
Workload in Hours	Independent Study Time 32, Study Time	in Lecture 28				
Credit points	2					
Course achievement	None					
Examination	Written elaboration					
Examination duration and	1					
scale						
Assignment for the	Electrical Engineering: Specialisation Con	ntrol and Power Systems Engineering: Elective Co	ompulsory			
Following Curricula	Mechatronics: Specialisation Intelligent S	Systems and Robotics: Elective Compulsory				
	Mechatronics: Specialisation System Des	sign: Elective Compulsony				

Course L1667: Control Lab V	
Тур	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Herbert Werner, Adwait Datar, Patrick Göttsch
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

Course L1668: Control Lab V	1
Тур	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Herbert Werner, Adwait Datar, Patrick Göttsch
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

Courses				
Title		Тур	Hrs/wk	СР
Advanced Topics in Control (L1803))	Seminar	2	2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	 Introduction to control syst Control theory and design optimal and robust control 			
Educational Objectives	After taking part successfully, stu	idents have reached the following learning results		
Professional Competence				
Knowledge	Students can explain modeStudents learn to apply ba	ern control. sic control concepts for different tasks		
Skills		ge about selected aspects of modern control, base oped results and present them to the participants re and give a presentation	d on specified literature	
Personal Competence				
Social Competence		eveloping solutions and present them ppropriate feedback and handle constructive critic	ism of their own results	
Autonomy	solution	ages and drawbacks of different forms of prese selves with a scientific field, are able of introduce ssion develops		
Workload in Hours	Independent Study Time 32, Stud	dy Time in Lecture 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and scale	90 min			
Assignment for the	Mechatronics: Specialisation Syst	em Design: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation Intel	lligent Systems and Robotics: Elective Compulsory	,	

Course L1803: Advanced Top	pics in Control
Тур	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe/SoSe
Content	Seminar on selected topics in modern control
Literature	To be specified

Courses						
	and Control of Autonomous Vehicles (L2869) n into Mobile Underwater Robotics (L1981)		Typ Integrated Lecture Project-/problem-based Learning	Hrs/wk 1 4	CP 1 5	
Module Responsible					-	
Admission Requirements	None					
Recommended Previous Knowledge	Mechanics IV, Applied Dynamics or Robot Numerical Treatment of Ordinary Differen					
	Control Systems Theory and Design					
Educational Objectives	After taking part successfully, students ha	ve reached the followi	ing learning results			
Professional Competence						
Knowledge	After successful completion of the module students demonstrate deeper knowledge and understanding in selected applicat areas of multibody dynamics and robotics					
Skills	Students are able					
	+ to think holistically					
	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibol systems					
	+ to describe dynamics problems mathem	natically				
	+ to implement dynamical problems on h	ardware				
Personal Competence						
Social Competence	Students are able to					
	+ solve problems in heterogeneous group	s and to document the	e corresponding results and prese	ent them		
Autonomy	Students are able to					
	+ assess their knowledge by means of exercises and projects.					
	+ acquaint themselves with the necessar	v knowledge to solve r	esearch oriented tasks.			
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70				
Credit points	6					
Course achievement	None					
Examination	Presentation					
	ТВА					
scale	Machakraniaa, Chasia Bashiar Intelli	shame and D-b-ti-	lastive Compulation			
Assignment for the Following Curricula	Mechatronics: Specialisation Intelligent Sy Mechatronics: Specialisation System Desi					
FOUOWING CURRICULA	INFORMATION STEPHINE					

Course L2869: Formulas and	ourse L2869: Formulas and Vehicles - Dynamics and Control of Autonomous Vehicles		
Тур	Integrated Lecture		
Hrs/wk	1		
CP	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Robert Seifried, Daniel-André Dücker		
Language	DE		
Cycle	WiSe		
Content			
Literature			

Course L1981: Formulas and	Vehicles - Introduction into Mobile Underwater Robotics
Тур	Project-/problem-based Learning
Hrs/wk	4
CP	5
Workload in Hours	Independent Study Time 94, Study Time in Lecture 56
Lecturer	Prof. Robert Seifried, Daniel-André Dücker
Language	DE
Cycle	WiSe
Content	
Literature	Seifried, R.: Dynamics of underactuated multibody systems, Springer, 2014
	Popp, K.; Schiehlen, W.: Ground vehicle dynamics, Springer, 2010

Module M0629: Intelli	gent Autonomous Agents ar	d Cognitive Robotics			
Courses					
Title		Тур	Hrs/wk	СР	
Intelligent Autonomous Agents and	Cognitive Robotics (L0341)	Lecture	2	4	
Intelligent Autonomous Agents and	Cognitive Robotics (L0512)	Recitation Section (small)	2	2	
Module Responsible	Rainer Marrone				
Admission Requirements	None				
Recommended Previous	Vectors, matrices, Calculus				
Knowledge					
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results			
Professional Competence					
Knowledge	Students can explain the agent abstracti	on, define intelligence in terms of rational behav	ior, and give detail	s about agent des	
		describe the main features of environments. The			
	can be discussed in terms of decision pr	oblems and algorithms for solving these probler	ms. For dealing wit	h uncertainty in re	
		how Bayesian networks can be employed as a k	-	-	
		. In addition, students can define decision maki			
		to the state of the environment. In this contex			
	solving (partially observable) Markov de	cision problems, and they can recall techniques	for measuring the	value of informati	
		ultaneous localization and mapping, and can ex	-		
		dination problems and decision making in a mult			
	of equilibria, social choice functions, votir	g protocol, and mechanism design techniques.			
Skills	Students can select an appropriate ager	t architecture for concrete agent application sce	enarios. For simplifi	ied agent applicat	
	students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesia				
	networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply				
	different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the				
		gs. In multi-agent situations students will apply t			
	states,e.g., Nash equilibria. For multi-age	nt decision making students will apply different ve	oting protocols and	compare and expl	
	the results.				
Personal Competence	Charlen to an a blacks "	- to such have with a three 🐨	En allah		
Social Competence	Students are able to discuss their solution	is to problems with others. They communicate in	English		
Autonomy	Students are able of checking their understanding of complex concepts by solving varaints of concrete problems				
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 minutes				
scale					
Assignment for the	Computer Science: Specialisation II: Intell	igence Engineering: Elective Compulsory			
Following Curricula	International Management and Engineering	ng: Specialisation II. Information Technology: Elec	tive Compulsory		
	Mechatronics: Technical Complementary	Course: Elective Compulsory			
	Mechatronics: Specialisation Intelligent S	stems and Robotics: Elective Compulsory			
	Biomedical Engineering: Specialisation Ar	tificial Organs and Regenerative Medicine: Electiv	e Compulsory		
	Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Me	edical Technology and Control Theory: Elective Co	ompulsory		
	Biomedical Engineering: Specialisation Ma	anagement and Business Administration: Elective	Compulsory		
	Theoretical Mechanical Engineering: Spec				

Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	 Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, produrule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexiti independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-ca complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be direct perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Mark assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanatio special cases: hidden Markov models, Kalman filters, Exact inferences and approximations Decision: utility theory, multivariate utility functions, dominance, decision networks, value of informatio Complex decisions: equential 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, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externali mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwait
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 1 11, 13-17
	2. Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005
	 Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridg University Press, 2009

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

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Courses				
Title		Тур	Hrs/wk	СР
Advanced Machine Learning (L232)		Lecture	2	3
Advanced Machine Learning (L232)		Recitation Section (small)	2	3
Module Responsible	-			
Admission Requirements	None			
Recommended Previous	1. Mathematics I-III			
Knowledge	2. Numerical Mathematics 1/ Numerics			
	 Programming skills, preferably in Pyth 	101		
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	Students are able to name, state and classi	fy state-of-the-art neural networks and their co	rresponding mathe	ematical basics. Th
	can assess the difficulties of different neural	networks.		
Skills	Students are able to implement, understand	, and, tailored to the field of application, apply r	neural networks.	
Personal Competence				
Social Competence	Students can			
	 develop and document joint solutions 	in small toams:		
	, , ,	eas and transfer them to other areas of applicat	oility:	
	 form a team to develop, build, and ad 		Jincy,	
		valice a software library.		
Autonomy	Students are able to			
	 correctly assess the time and effort or 	f solf defined work:		
		etical and practical excercises are better solved	individually or in a	toom:
	 define test problems for testing and e 			Leann,
		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	Oral exam			
Examination duration and	25 min			
scale				
Assignment for the	Computer Science: Specialisation III. Mathem	natics: Elective Compulsory		
Following Curricula	Computer Science in Engineering: Specialisa	ition III. Mathematics: Elective Compulsory		
	Mechatronics: Specialisation Intelligent System	ems and Robotics: Elective Compulsory		
	Mechatronics: Technical Complementary Co	urse: Elective Compulsory		
	Technomathematics: Specialisation I. Mathe	matics: Elective Compulsory		
	Theoretical Mechanical Engineering: Special	isation Bobotics and Computer Science: Elective	Compulsory	

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

Course L2323: Advanced Ma	purse L2323: Advanced Machine Learning		
Тур	Recitation Section (small)		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Dr. Jens-Peter Zemke		
Language	DE/EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses						
Title			Torre		CP.	
Hitle Mathematical Image Processing (L(0001)		Typ Lecture	Hrs/wk 3	СР 4	
Mathematical Image Processing (LC			Recitation Section		2	
Module Responsible				(_	
Admission Requirements						
Recommended Previous						
Knowledge	 Analysis: partia 	derivatives, gradient, dire	ectional derivative			
Kilowieuge		eigenvalues, least square	solution of a linear system			
Educational Objectives	After taking part succe	esfully students have rea	ched the following learning results			
Professional Competence		solution, scudents have rea	ched the following learning results			
	Students are able to					
Knowledge	Students are able to					
	characterize an	d compare diffusion equat	ions			
		tary methods of image pro				
	 explain method 	s of image segmentation a	nd registration			
	 sketch and inte 	rrelate basic concepts of f	unctional analysis			
Skills	Students are able to					
	 implement and apply elementary methods of image processing 					
		ly modern methods of ima				
Personal Competence						
Social Competence			rogeneously composed teams (i.	e., teams from different	study programs a	
	background knowledg	e) and to explain theoretic	al foundations.			
Autonomy						
	 Students are ca 	 Students are capable of checking their understanding of complex concepts on their own. They can specify open question providely and know where to get help in calving them 				
		precisely and know where to get help in solving them.				
	precisely and ki			where the standard st		
	precisely and ki • Students have		olving them. stence to be able to work for lor	nger periods in a goal-orie	nted manner on h	
	precisely and ki			nger periods in a goal-orie	nted manner on h	
	precisely and ki • Students have problems.		stence to be able to work for lor	iger periods in a goal-orie	nted manner on h	
	precisely and ki • Students have problems.	developed sufficient pers	stence to be able to work for lor	nger periods in a goal-orie	nted manner on h	
Workload in Hours	precisely and ku Students have problems. Independent Study Tir 6	developed sufficient pers	stence to be able to work for lor	nger periods in a goal-orie	nted manner on h	
Workload in Hours Credit points	precisely and ki Students have problems. Independent Study Tir 6 None	developed sufficient pers	stence to be able to work for lor	nger periods in a goal-orie	nted manner on h	
Workload in Hours Credit points Course achievement	precisely and ki Students have problems. Independent Study Tir 6 None Oral exam	developed sufficient pers	stence to be able to work for lor	nger periods in a goal-orie	nted manner on h	
Workload in Hours Credit points Course achievement Examination	precisely and kr Students have problems. Independent Study Tir 6 None Oral exam 20 min	developed sufficient pers	stence to be able to work for lor	nger periods in a goal-orie	nted manner on h	
Workload in Hours Credit points Course achievement Examination Examination duration and	precisely and kr Students have problems. Independent Study Tir 6 None Oral exam 20 min	developed sufficient personne 124, Study Time in Lec	stence to be able to work for lor		nted manner on h	
Workload in Hours Credit points Course achievement Examination Examination duration and scale	 precisely and ki Students have problems. Independent Study Tir 6 None Oral exam 20 min Bioprocess Engineerin 	developed sufficient personne 124, Study Time in Lec	stence to be able to work for lor ture 56 al Bioprocess Engineering: Electiv		nted manner on h	
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	precisely and ku • Students have problems. Independent Study Tir 6 None Oral exam 20 min Bioprocess Engineerin Computer Science: Sp	developed sufficient personne 124, Study Time in Lec g: Specialisation A - Gener ecialisation III. Mathematic	stence to be able to work for lor ture 56 al Bioprocess Engineering: Electiv	e Compulsory	nted manner on h	
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	precisely and ku Students have problems. Independent Study Tir 6 None Oral exam 20 min Bioprocess Engineerin Computer Science: Sp Computer Science in E	developed sufficient persi ne 124, Study Time in Lec g: Specialisation A - Gener ecialisation III. Mathematic ingineering: Specialisation	stence to be able to work for lor ture 56 al Bioprocess Engineering: Electiv s: Elective Compulsory	e Compulsory sory	nted manner on h	
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Precisely and ku Students have problems. Independent Study Tir 6 None Oral exam 20 min Bioprocess Engineerin Computer Science: Sp Computer Science in E Interdisciplinary Mathe	developed sufficient persi ne 124, Study Time in Lec g: Specialisation A - Gener ecialisation III. Mathematic ingineering: Specialisation	stence to be able to work for lor ture 56 al Bioprocess Engineering: Electiv s: Elective Compulsory III. Mathematics: Elective Compul nputational Methods in Biomedica	e Compulsory sory	nted manner on h	
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	precisely and ku Students have problems. Independent Study Tir 6 None Oral exam 20 min Bioprocess Engineerin Computer Science: Sp Computer Science in E Interdisciplinary Mathe Mechatronics: Technic	developed sufficient persi ne 124, Study Time in Lec g: Specialisation A - Gener ecialisation III. Mathematic ingineering: Specialisation ematics: Specialisation Cor	stence to be able to work for lor ture 56 al Bioprocess Engineering: Electiv s: Elective Compulsory III. Mathematics: Elective Compul- nputational Methods in Biomedica : Elective Compulsory	e Compulsory sory	nted manner on h	
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	precisely and ku Students have problems. Independent Study Tir 6 None Oral exam 20 min Bioprocess Engineerin Computer Science: Sp Computer Science in E Interdisciplinary Mathe Mechatronics: Speciali	developed sufficient persi ne 124, Study Time in Lec g: Specialisation A - Gener ecialisation III. Mathematic ingineering: Specialisation ematics: Specialisation Cor al Complementary Course sation System Design: Ele	stence to be able to work for lor ture 56 al Bioprocess Engineering: Electiv s: Elective Compulsory III. Mathematics: Elective Compul- nputational Methods in Biomedica : Elective Compulsory	e Compulsory sory I Imaging: Compulsory	nted manner on h	
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	precisely and ku Students have problems. Independent Study Tir 6 None Oral exam 20 min Bioprocess Engineerin Computer Science in E Interdisciplinary Mathe Mechatronics: Speciali Mechatronics: Speciali	developed sufficient persi ne 124, Study Time in Lec g: Specialisation A - Gener ecialisation III. Mathematic ingineering: Specialisation ematics: Specialisation Cor al Complementary Course sation System Design: Ele	stence to be able to work for lor ture 56 al Bioprocess Engineering: Electiv s: Elective Compulsory III. Mathematics: Elective Compul- nputational Methods in Biomedica : Elective Compulsory ctive Compulsory and Robotics: Elective Compulsory	e Compulsory sory I Imaging: Compulsory	nted manner on h	
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	precisely and ku Students have problems. Independent Study Tir 6 Oral exam 20 min Bioprocess Engineerin Computer Science: Sp Computer Science in E Interdisciplinary Mathe Mechatronics: Speciali Mechatronics: Speciali Technomathematics: S Theoretical Mechanica	developed sufficient persi ne 124, Study Time in Lec g: Specialisation A - Gener ecialisation III. Mathematic ingineering: Specialisation ematics: Specialisation Cor al Complementary Course sation System Design: Ele sation Intelligent Systems Specialisation I. Mathemati I Engineering: Specialisati	stence to be able to work for lor ture 56 al Bioprocess Engineering: Electiv s: Elective Compulsory III. Mathematics: Elective Compul- nputational Methods in Biomedica : Elective Compulsory ctive Compulsory and Robotics: Elective Compulsory	e Compulsory sory I Imaging: Compulsory Y	nted manner on h	

Course L0991: Mathematical	Image Processing		
Тур	Lecture		
Hrs/wk	3		
CP	4		
Workload in Hours	ependent 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	urse L0992: Mathematical Image Processing		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	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		

Courses				
Title		Тур	Hrs/wk	СР
Image Processing (L2443)		Lecture	2	4
Image Processing (L2444)		Recitation Section (small)	2	2
Module Responsible	Prof. Tobias Knopp			
Admission Requirements	None			
Recommended Previous	Signal and Systems			
Knowledge				
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge	The students know about			
	visual perception			
	 multidimensional signal processing 			
	 sampling and sampling theorem 			
	• filtering			
	image enhancement			
	edge detection			
	 multi-resolution procedures: Gauss and La 	aplace pyramid, wavelets		
	image compression			
	 image segmentation 			
	 morphological image processing 			
Skills	The students can			
	 analyze, process, and improve multidimer 	nsional image data		
	 implement simple compression algorithm 			
	design custom filters for specific application			
Personal Competence				
	Students can work on complex problems both in	dependently and in teams. They can exchan	ne ideas with eac	h other and use th
Social competence	individual strengths to solve the problem.	dependently and in teams. They can exchan	ge lucus with cut	
	individual screngths to solve the problem.			
Autonomy	Students are able to independently investigate a	a complex problem and assess which competence	encies are require	ed to solve it.
Workload in Hours	Independent Study Time 124, Study Time in Lec	ture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Data Science: Core Qualification: Elective Compu	JIsory		
Following Curricula	Data Science: Specialisation I. Mathematics/Com	puter Science: Elective Compulsory		
	Electrical Engineering: Specialisation Information	and Communication Systems: Elective Com	ipulsory	
	Electrical Engineering: Specialisation Medical Te	chnology: Elective Compulsory		
	Information and Communication Systems: Sp	ecialisation Secure and Dependable IT S	ystems, Focus S	oftware and Sign
	Processing: Elective Compulsory			
	Information and Communication Systems: Specia	alisation Communication Systems, Focus Sig	nal Processing: Ele	ective Compulsory
	International Management and Engineering: Spe	cialisation II. Information Technology: Electiv	e Compulsory	
	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Ele	ctive Compulsory		
	Microelectronics and Microsystems: Specialisatic	on Communication and Signal Processing: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Specialisati	on Robotics and Computer Science: Elective	Compulsory	

Course L2443: Image Proces	sing
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Tobias Knopp
Language	DE/EN
Cycle	WiSe
Content	 Visual perception Multidimensional signal processing Sampling and sampling theorem Filtering Image enhancement Edge detection Multi-resolution procedures: Gauss and Laplace pyramid, wavelets Image Compression Segmentation Morphological image processing
Literature	Bredies/Lorenz, Mathematische Bildverarbeitung, Vieweg, 2011 Pratt, Digital Image Processing, Wiley, 2001 Bernd Jähne: Digitale Bildverarbeitung - Springer, Berlin 2005

Course L2444: Image Proces	ourse L2444: Image Processing	
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Tobias Knopp	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Typ Project-/problem-based Learning	Hrs/wk 6	СР 6
Project-/problem-based Learning		
	6	6
e reached the following learning results		
e reached the following learning results		
e reached the following learning results		
e reached the following learning results		
e reached the following learning results		
Lecture 84		
	Engineering: Elective Compulsory Traffic: Elective Compulsory gineering: Elective Compulsory :al Engineering: Elective Compulsory tems and Robotics: Elective Compulsory	Engineering: Elective Compulsory Traffic: Elective Compulsory gineering: Elective Compulsory

,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	roject-/problem-based Learning
Hrs/wk 6	
CP 6	
Workload in Hours In	ndependent Study Time 96, Study Time in Lecture 84
Lecturer Pr	rof. Kay Smarsly, Jan Stührenberg, Mathias Worm
Language DI	E/EN
Cycle W	ViSe
Content	 Introduction: Robotics in civil engineering Presentation of potential topics Programming of algorithms in Python Application of software systems: LINUX distribution, ROS, CloudCompare, Application of hardware systems: Petoi Bittle Dog, Raspberry Pi, Arduino, sensing Topics considered for robotics using the Petoi Bittle Dog: Movement Use of sensors (camera, infrared,) Data structures/data acquisition Programming Topics technically relevant to building inspection: Geodetic evaluations Image processing Localization
	ock/Linner: Construction Robotics
	erl et al.: Soft Robotics
Pa	asquale: New Laws of robotics

Courses						
ītle			Тур		Hrs/wk	СР
ptics for Engineers (L2437)			Lecture		3	3
ptics for Engineers (L2438)			Project-/prob	em-based Learning	3	3
Module Responsible	Prof. Thorsten Kern					
Admission Requirements	None					
Recommended Previous	- Basics of physics					
Knowledge						
Educational Objectives	After taking part suc	cessfully, students have r	eached the following learning re	sults		
Professional Competence						
Knowledge	Teaching subject ist	the design of simple optic	al systems for illumination and	imaging optics		
	De sie velvee f		halfer on the scheme of a second			
		or optical systems and lig				
		ck-bodies, color-perceptic				
	-	und their characterization	1			
	Photometrics					
	Ray-Optics					
	Matrix-Optics					
	 Stops, Pupils a 					
	 Light-field Tec 					
	Introduction to Wave-Optics					
	 Introduction to 	o Holography				
Skills	Understandings of op	ptics as part of light and e	lectromagnetic spectrum. Desig	jn rules, approach t	o designing o	ptics
Personal Competence						
Social Competence						
Autonomy						
Workload in Hours	Independent Study T	Time 96, Study Time in Le	cture 84			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	Yes None	Subject theoretical	andTeilnahme an Laborübung	en und Simulation		
		practical work				
Examination	Oral exam					
Examination duration and	30 min					
scale						
Assignment for the	Electrical Engineerin	g: Specialisation Microwa	ve Engineering, Optics, and Elec	tromagnetic Compa	atibility: Electi	ive Compulsory
Following Curricula	Mechatronics: Techn	ical Complementary Cour	se: Elective Compulsory			
-	Mechatronics: Specia	alisation Intelligent Syster	ns and Robotics: Elective Comp	ulsory		
		alisation System Design: E		2 		
			lification: Elective Compulsory			

Course L2437: Optics for Eng	jineers	
Тур	Lecture	
Hrs/wk		
CP	3	
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Prof. Thorsten Kern	
Language	EN	
Cycle	WiSe	
Content	 Basic values for optical systems and lighting technology Spectrum, black-bodies, color-perception Light-Sources und their characterization Photometrics Ray-Optics Matrix-Optics Stops, Pupils and Windows Light-field Technology Introduction to Wave-Optics Introduction to Holography 	
Literature		

Course L2438: Optics for Eng	urse L2438: Optics for Engineers	
Тур	Project-/problem-based Learning	
Hrs/wk	3	
CP	3	
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Prof. Thorsten Kern	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses						
Title			Тур	н	lrs/wk	СР
Haptic Technology for Human-Machine-Interfaces (HMI) (L2439)		Lecture	4		3	
Haptic Technology for Human-Mach	ine-Interfaces (HMI) (L2859)		Project-/problem-b	based Learning 2		3
Module Responsible	Prof. Thorsten Kern					
Admission Requirements	None					
Recommended Previous	We recommend knowledge	ge in the areas of ge	neral engineering sciences, mechat	ronics and/or con	trol-engine	ering. However a
Knowledge	neighbouring technical areas like mechanical-engineering or even process-engineers can join the course and will be introduce			ill be introduced i		
	the content properly.					
Educational Objectives	After taking part successf	ully, students have re	ached the following learning results	5		
Professional Competence						
Knowledge	This course is an introdu	iction to the design	nethods and design-requirements	to consider when	creating I	haptic systems fr
	scratch. It covers a physi	iological part, an actu	ator development part, and goes u	up to fundamenta	ls of highe	r system integrat
	with consideration on co	ntrol theory for mor	e complex projects. Beside design	-related topics, it	gives a v	aluable overview
	existing haptic application	ons and research in	that field with many examples. T	his is supported	by on-site	experiments in
	laboratories of M-4.					
	 Motivation and ann 	lightion of bontic qual				
	Motivation and app	incation of naptic syst	ems			
	Haptic perception	n in direct such as inte	vo etia e			
	The role of the use		raction			
	Development of ha	. ,				
	Identification of rec					
	 System-structure a Kinematic fundame 					
	Actuation & Sensor		ic applications			
	Control and system		a houting			
	 Fundamental consi 	derations in simulatir	g naptics			
Skills	Executing the course the	e competency will be	developed to apply the general e	engineering capal	bilities of t	he individual cou
	towards the design and application of active haptic systems. The resulting competencies will open an entry into specialize					
	position in avionic-industr	ries, automotive-indus	try and consumer-device-developm	nent.		
Personal Competence						
Social Competence	As a side-effect this mod	dule teaches basics	of a general design for human-ma	chine-interfaces,	independe	nt from the spec
			o execute user-studies, judge on u			
	requirements which are c	ommon when dealing	with subjective perception.			
Autonomy	Independent design-capability of haptic systems, general competency in engineering from a design-perspective					
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84					
Credit points	6					
Course achievement	Compulsory Bonus For	rm	Description			
	Yes 20 % Su	bject theoretical	andDurchführung von Laborversuc	hen		
	pra	actical work				
Examination	Subject theoretical and pr	ractical work				
Examination duration and	30 min					
scale						
Assignment for the	Mechatronics: Technical C	Complementary Cours	e: Elective Compulsory			
-			s and Robotics: Elective Compulsor	v		
	Mechatronics: Specialisat					
	Theoretical Mechanical Er					

Тур	Lecture
Hrs/wk	4
СР	3
Workload in Hours	Independent Study Time 34, Study Time in Lecture 56
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	WiSe
Content	This course is an introduction to the design methods and design-requirements to consider when creating haptic systems from
	scratch. It covers a physiological part, an actuator development part, and goes up to fundamentals of higher system integratior
	with consideration on control theory for more complex projects. Beside design-related topics, it gives a valuable overview or
	existing haptic applications and research in that field with many examples.
	Motivation and application of haptic systems
	Haptic perception
	The role of the user in direct system interaction
	Development of haptic systems
	Identification of requirements
	System-structure and control
	Kinematic fundamentals
	Actuation & Sensors technology for haptic applications
	Control and system-design aspects
	Fundamental considerations in simulating haptics
Literature	

course 12039: naptic rechnology for numan-machine-interfaces (nmi)		
Тур	ct-/problem-based Learning	
Hrs/wk		
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Thorsten Kern	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Specialization System Design

In the system design specialization, graduates learn how to work systematically and methodically on challenging design tasks.

They have broad knowledge of new development methods, are able to select appropriate solution strategies and use these autonomously to develop new products. They are qualified to use the approaches of integrated system development, such as simulation or modern testing procedures.

Module M0752: Nonlinear Dynamics

Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
	5 5			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concep	ts in Nonlinear Dynamics and t	o develop and resea	irch new terms and
	concepts.			
	Students are able to apply existing methods and procesu	res of Nonlinear Dynamics and to	develop novel meth	ods and procedures
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks indivi	idually and to identify and follow	up novel research ta	sks by themselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Aircraft Systems Engineering: Core Qualification: Elective	Compulsory		
Following Curricula	International Management and Engineering: Specialisatio			
	Mechanical Engineering and Management: Specialisation		ory	
	Mechatronics: Specialisation System Design: Elective Con			
	Mechatronics: Specialisation Intelligent Systems and Rob		Commission of the second	
	Biomedical Engineering: Specialisation Artificial Organs a Biomedical Engineering: Specialisation Implants and Endo	-		
	Biomedical Engineering: Specialisation Implants and Endo Biomedical Engineering: Specialisation Medical Technolog			
	Biomedical Engineering: Specialisation Medical Technolog Biomedical Engineering: Specialisation Management and			
	Product Development, Materials and Production: Core Qu		compuisory	
	Theoretical Mechanical Engineering: Core Qualification: E			

Course L0702: Nonlinear Dynamics	
Тур	Integrated Lecture
Hrs/wk	4
CP	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.

Module M0803: Embe	dded Systems				
Courses					
Title		Тур	Hrs/wk	СР	
Embedded Systems (L0805)		Lecture	3	4	
Embedded Systems (L0806)		Recitation Section (small)	1	2	
Module Responsible	Prof. Heiko Falk				
Admission Requirements	None				
Recommended Previous	Computer Engineering				
Knowledge	After whether a set of the set of	the full surface to surface and surface			
	After taking part successfully, students have reached	the following learning results			
Professional Competence	Embodded systems can be defined as information or	acassing systems ambaddad into anclas	ing products. Th	is course teaches t	
Knowledge	Embedded systems can be defined as information pr foundations of such systems. In particular, it deals w				
	their specification languages (models of computation				
	specification of real-time applications, translations be			, , , ,	
	Another part covers the hardware of embedded sy				
	hardware, embedded processors, memories, energy				
	introduction into real-time operating systems, mide systems using hardware/software co-design (hardwa				
	efficient realizations, compilers for embedded proces			Sectifications, ener	
Skills	After having attended the course, students shall be able to realize simple embedded systems. The students shall realize which				
	relevant parts of technological competences to use in order to obtain a functional embedded systems. In particular, they shall be				
	able to compare different models of computations and feasible techniques for system-level design. They shall be able to judge				
Demonstration of the second	which areas of embedded system design specific risk	s exist.			
Personal Competence	Students are able to solve similar problems alone or i	n a group and to procept the results acc	ordingly		
Social Competence	Students are able to solve similar problems alone or i	n a group and to present the results acc	ordingly.		
Autonomy	Students are able to acquire new knowledge from spe	ecific literature and to associate this kno	wledge with othe	er classes.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56			
Credit points		50			
Course achievement		escription			
	Yes 10 % Subject theoretical and				
	practical work				
Examination	Written exam				
Examination duration and	90 minutes, contents of course and labs				
scale					
Assignment for the	General Engineering Science (German program, 7 ser	mester): Specialisation Computer Scienc	e: Compulsory		
Following Curricula	Computer Science: Specialisation Computer and Soft	ware Engineering: Elective Compulsory			
	Computer Science: Specialisation I. Computer and So		1		
	Electrical Engineering: Core Qualification: Elective Co				
	Engineering Science: Specialisation Mechatronics: Ele				
	Aircraft Systems Engineering: Core Qualification: Elec General Engineering Science (English program, 7 sen		ctive Compulsory	,	
	Computational Science and Engineering: Core Qualifi				
	Mechatronics: Specialisation System Design: Elective				
	Mechatronics: Specialisation Intelligent Systems and				
	Mechatronics: Core Qualification: Elective Compulsor	y.			
	Microelectronics and Microsystems: Specialisation En	bedded Systems: Elective Compulsory			
Course L0805: Embedded Sy Typ	stems Lecture				
Hrs/wk					
CP	4				
Workload in Hours	Independent Study Time 78, Study Time in Lecture 4.	2			
	Prof. Heiko Falk	-			
Lecturer					

Lecturer	
Language	EN
Cycle	SoSe
Content	 Introduction Specifications and Modeling Embedded/Cyber-Physical Systems Hardware System Software Evaluation and Validation Mapping of Applications to Execution Platforms Optimization
Literature	 Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2 nd Edition, Springer, 2012., Springer, 2012.

Course L0806: Embedded Sy	ourse L0806: Embedded Systems		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Heiko Falk		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses						
Title		Тур	Hrs/wk	СР		
Technical Acoustics I (Acoustic Way	ves, Noise Protection, Psycho Acoustics) (L0516)	Lecture	2	3		
Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics) (L0518) Recitation Section (large) 2						
Module Responsible						
Admission Requirements						
	Mechanics I (Statics, Mechanics of Materials) and Mech	hanics II (Hydrostatics, Kinematics, Dyn	amics)			
Knowledge	Mathematics I, II, III (in particular differential equation	s)				
Educational Objectives	After taking part successfully, students have reached	the following learning results				
Professional Competence						
Knowledge	The students possess an in-depth knowledge in acou	stics regarding acoustic waves, noise	protection, and p	osycho acoustics a		
	are able to give an overview of the corresponding theoretical and methodical basis.					
Skills	Skills The students are capable to handle engineering problems in acoustics by theory-based application of the					
Skiils	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. Possi			the module. Possil		
,	conflicting issues and limitations can be identified and the results are critically scrutinized.					
	Independent Study Time 124, Study Time in Lecture 5	6				
Credit points						
Course achievement						
Examination						
Examination duration and	90 min					
scale						
-	Energy Systems: Core Qualification: Elective Compulse	•				
Following Curricula	Aircraft Systems Engineering: Core Qualification: Elect					
	International Management and Engineering: Specialisa	•	puisory			
	Mechatronics: Specialisation System Design: Elective					
	Product Development, Materials and Production: Core	Quanneation. Elective Compulsory				
	Technomathematics: Specialisation III. Engineering Sc	ience: Elective Compulsory				

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

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

C						
Courses				_		
Title				Тур	Hrs/wk	СР
Boundary Element Methods (L0523 Boundary Element Methods (L0524				Lecture Recitation Section (larg	2 (e) 2	3 3
		e		Recitation Section (larg	2	5
Module Responsible		ſ				
Admission Requirements	-					
				hanics II (Hydrostatics, Kinematic	s, Dynamics)	
Knowledge	Mathematics I, II, III (i	in particular diff	erential equation	s)		
Educational Objectives	After taking part succ	cessfully, studer	its have reached	the following learning results		
Professional Competence		,,,				
•	The students posses	s an in-denth k	nowledge regard	ing the derivation of the bounda	ry element method a	nd are able to give
Knowledge	overview of the theor				ry clement method a	na are able to give
				le metrioù.		
Skills				problems by formulating suit	able boundary elem	ents, assembling
	corresponding system	m matrices, and	solving the result	ting system of equations.		
Personal Competence						
Social Competence	Students can work in	small groups o	n specific problen	ns to arrive at joint solutions.		
Autonomy				nging computational problems a	nd develop own bound	dary element routi
	Problems can be iden	ntified and the r	esults are criticall	ly scrutinized.		
Werkload in Heure	Independent Chudu T	ine 124 Chudu	Times in Lookung (6		
	Independent Study Ti	ime 124, Study	Time in Lecture 3	00		
Credit points		Form	Do	scription		
Course achievement	No 20 %	Midterm	De	scription		
Examination	-	Materin				
Examination duration and	-					
	90 1110					
scale						
Assignment for the				g: Elective Compulsory		
Following Curricula	5 5 1		-	ering: Elective Compulsory		
	Civil Engineering: Spe					
	Energy Systems: Core	e Qualification:	Elective Compuls	ory		
	Mechanical Engineeri		and the Constantial lines		oduction: Elective Com	npulsory
	Heenanical Engineeri	ing and Manage	ment: Specialisat	ion Product Development and Pr		
	Mechatronics: Specia					
	Mechatronics: Specia	alisation System	Design: Elective		ry	
	Mechatronics: Specia Product Development	alisation System It, Materials and	Design: Elective Production: Core	Compulsory	ry	

Course L0523: Boundary Eler	Course L0523: Boundary Element Methods		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Otto von Estorff		
Language	EN		
Cycle	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		
1			

Course L0524: Boundary Eler	urse L0524: Boundary Element Methods		
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		

Courses				
		T	I los toda	<u></u>
Title Systems Engineering (L1547)		Typ Lecture	Hrs/wk 3	CP 4
Systems Engineering (L1547)		Recitation Section (large)	1	2
Module Responsible	Prof. Ralf God	neeration Section (arge)	-	-
Admission Requirements	None			
Recommended Previous				
Knowledge	Basic knowledge in: • Mathematics			
Kilowiedge	Mathematics Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Control Systems			
	Previous knowledge in:			
	Aircraft Cabin Systems			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
	After taking part successfully, students have reached	the following learning results		
Professional Competence	Chudanha ana akia ha			
Knowledge	Students are able to:	atheda and tools for the development of	f. commissi Custom	-
	understand systems engineering process models, n		r complex System	15
	describe innovation processes and the need for tec			
	 explain the aircraft development process and the p explain the system development process, including 			
	 explain the system development process, including identify environmental conditions and test procedu 			
			oonto onginooring	(MPDE)
	 value the methodology of requirements-based engi 	leening (KBE) and model-based requirem	nents engineering	(MBRE)
Skills	Students are able to:			
plan the process for the development of complex Systems				
	 organize the development phases and developmen 	Tasks		
	 assign required business activities and technical Ta 	sks		
	 apply systems engineering methods and tools 			
Personal Competence				
-	Students are able to:			
Social Competence		ant team and integrate themselves with	their role in the e	vorall process
	 understand their responsibilities within a developm 	ent team and integrate themselves with	their role in the o	verall process
Autonomy	Students are able to:			
	 interact and communicate in a development team value 	hich has distributed tasks		
	Independent Study Time 124, Study Time in Lecture	66		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration and	120 Minutes			
scale				
Assignment for the	Aircraft Systems Engineering: Core Qualification: Con	pulsory		
Following Curricula			-	
	International Management and Engineering: Specialis		iction: Elective Co	ompulsory
	Mechatronics: Specialisation System Design: Elective			
	Mechatronics: Specialisation Intelligent Systems and			
	Product Development, Materials and Production: Spec		3	
	Product Development, Materials and Production: Spec		-	
	Preduct Development Meterials and Dreduction, Cro-	inlightion Materials, Elective Compulson		
	Product Development, Materials and Production: Spec Theoretical Mechanical Engineering: Specialisation Ai			

Course L1547: Systems Engi	neering
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and 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)
Litoratura	- Skript zur Vorlesung
Literature	- diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE)
	- diverse Normen and Kichamen (LASA, FAA, KICA, SAE) - Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010
	- NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007
	- Hinsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation luftfahrttechnischer Betriebe. Springer, 2010
	- De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010
	- Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt.Verlag, 2008

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

Courses			
litle	Тур	Hrs/wk	СР
Module Responsible			
Admission Requirements			
Recommended Previous	See selected module according to FSPO		
Knowledge			
,	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	see selected module according to FSPO		
Skills	see selected module according to FSPO		
Personal Competence			
	see selected module according to FSPO		
Social Competence	see selected module according to FSFO		
Autonomy	see selected module according to FSPO		
Autonomy	see selected module according to 1 300		
Workload in Hours	Depends on choice of courses		
Credit points	6		
Assignment for the	Mechatronics: Specialisation System Design: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory		

Courses			
Title	Тур	Hrs/wk	СР
Applied Automation (L1592)	Project-/problem-based Learnir	g 3	3
Ergonomics (L0653)	Lecture	2	3
Advanced Training Course SE-ZER	(L2739) Project-/problem-based Learnir	g 2	3
- Development Management for Med		2	3
Fatigue & Damage Tolerance (L03	L0) Lecture	2	3
Industry 4.0 for engineers (L2012)	Lecture	2	3
Microcontroller Circuits: Implement	ation in Hardware and Software (L0087) Seminar	2	2
Microsystems Technology (L0724)	Lecture	2	4
Model-Based Systems Engineering	(MBSE) with SysML/UML (L1551) Project-/problem-based Learning	q 3	3
Sustainable Industrial Production (2	3
Process Measurement Engineering		2	3
Process Measurement Engineering		1	1
Feedback Control in Medical Techn	-	2	3
Applied Dynamics (L1630)	Lecture	2	3
Module Responsible	NN		
Admission Requirements			
Recommended Previous			
Knowledge	None		
÷	A firm to block and an an official structure to the state of the following structure state		
	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge			
		different specia	al fields or applic
	 Students are able to express their extended knowledge and discuss the connection of 	different specia	al fields or applic
	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics 	different specia	al fields or applic
	 Students are able to express their extended knowledge and discuss the connection of 	different specia	al fields or applic
	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics 	different specia	al fields or applic
	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics 	different specia	al fields or applio
Skills	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other 		al fields or applio
Skills	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other 		al fields or applic
Skills	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other 	d areas	
Skills	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected 	d areas	
Skills	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected 	d areas	
Skills Personal Competence	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected 	d areas	
Personal Competence	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selection. Students are able to transfer learned skills to new and unknown problems and can developed and the selection. 	d areas	
Personal Competence Social Competence	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selection. Students are able to transfer learned skills to new and unknown problems and can developed and the selection. 	d areas	
Personal Competence	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selection. Students are able to transfer learned skills to new and unknown problems and can developed and the selection. 	d areas lop own solutio	
Personal Competence Social Competence	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selecte Students are able to transfer learned skills to new and unknown problems and can developed None	d areas lop own solutio	
Personal Competence Social Competence	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selecte Students are able to transfer learned skills to new and unknown problems and can developed None	d areas lop own solutio	
Personal Competence Social Competence Autonomy	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selecte Students are able to transfer learned skills to new and unknown problems and can developed None	d areas lop own solutio	
Personal Competence Social Competence Autonomy Workload in Hours	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selection. Students are able to transfer learned skills to new and unknown problems and can develop. None Students are able to develop their knowledge and skills by autonomous election of courses 	d areas lop own solutio	
Personal Competence Social Competence Autonomy Workload in Hours Credit points	 Students are able to express their extended knowledge and discuss the connection of areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selection. Students are able to transfer learned skills to new and unknown problems and can develop. None Students are able to develop their knowledge and skills by autonomous election of courses 	d areas lop own solutio	

Course L159	2: Applied Automation
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in	Independent Study Time 48, Study Time in Lecture 42
Hours	
Examination	Mündliche Prüfung
Form	
Examination	30 Minuten
duration	
and scale	
	Prof. Thorsten Schüppstuhl
Language	
Cycle	WiSe
	-Project Based Learning -Robot Operating System -Robot structure and description -Motion description -Calibration -Accuracy
Literature	John J. Craig Introduction to Robotics - Mechanics and Control ISBN: 0131236296 Pearson Education, Inc., 2005 Stefan Hesse Grundlagen der Handhabungstechnik ISBN: 3446418725 München Hanser, 2010 K. Thulasiraman and M. N. S. Swamy Graphs: Theory and Algorithms ISBN: 9781118033104 %CITAVIPICKER£9781118033104£Titel anhand dieser ISBN in Citavi-Projekt übernehmen£% John Wüey & Sons, Inc., 1992

Course L0653: Ergonomics	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Armin Bossemeyer
Language	DE
Cycle	WiSe
Content	
Literature	

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

Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 Minuten
scale	
Lecturer	NN, Dr. Johannes Nicolas Gebhardt
Language	DE
Cycle	SoSe
Content	 Processes and methods of product development - from idea to market launch identification of market and technology potentials development of a common product architecture Synchronized product development across all engineering disciplines product validation incl. customer view Steering and optimization of product development Design of processes for product development IT systems for product development Establishment of management standards Typical types of organization
Literature	 Bender: Embedded Systems - qualitätsorientierte Entwicklung Ehrlenspiel: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit Gausemeier/Ebbesmeyer/Kallmeyer: Produktinnovation - Strategische Planung und Entwicklung der Produkte von morger Haberfellner/de Weck/Fricke/Vössner: Systems Engineering: Grundlagen und Anwendung Lindemann: Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden Pahl/Beitz: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung. Methoden und Anwendung VDI-Richtlinie 2206: Entwicklungsmethodik für mechatronische Systeme

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

Course L2012: Industry 4.0 f	ourse L2012: Industry 4.0 for engineers	
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	120 min	
scale		
Lecturer	Prof. Thorsten Schüppstuhl	
Language	DE	
Cycle	SoSe	
Content		
Literature		

Course L0087: Microcontrolle	er Circuits: Implementation in Hardware and Software
Тур	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and	10 min. Vortrag + anschließende Diskussion
scale	
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe/SoSe
Content	
Literature	ATmega16A 8-bit Microcontroller with 16K Bytes In-System Programmable Flash - DATASHEET, Atmel Corporation 2014
	Atmel AVR 8-bit Instruction Set Instruction Set Manual, Atmel Corporation 2016

Course L0724: Microsystems	Technology
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Somiconductor Technology Resident Lithography (wefer fabrication, photolithography, improving recolution, payt generation)
	Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting)
	 Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing)
	 Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, Cryo process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures;
	 Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer)
	 Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process)
	 Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip)
	 Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a-chip, microanalytics) MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system,
	 stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration) Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling:
	 multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
Literature	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

Тур	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung
Examination duration and	ca. 10 Seiten
scale	
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 language
	SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Base
	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
Literature	- Skipt zur Vollesung - Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008
	- Weintens, T.: Systems Engineering mit Sysmi, one. Modellering, Analyse, Design. 2. Aurage, dpunkt. verag, 2008 - Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011
	- noit, J., reny, S.A., brownsword, M.: Model-based Requirements Engineering. Institution Engineering & Tech, 2011

Тур	Lecture
Hrs/wk	
CP	3
	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur 60 min
scale	
	Dr. Simon Markus Kothe
Language	
Cycle	
-	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufactur
	processes that change the form and physical properties of raw materials. Manufacturing is a central driver of econo development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities resi in enormous global energy and material demands that are harmful to both the environment and people. Historically, indusi activities were mostly oriented towards economic constraints, while social and environmental consequences were only ha considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the nat regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. Thi emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Ear annual regenerative capacity.
	This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cyclo products. For this, the following topics will be highlighted:
	- Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance tomorrow's manufacturing;
	- raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for environmental impact of manufactured products;
	- Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy a resource efficiency;
	- Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps modeling (1), evaluating (2) and improving (3);
	- Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA);
	- Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product cycle assessment.
Literature	Literatur:
	- Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing.
	- Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Ch Springer International Publishing.
	- Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapo Springer.
	- Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer Internatic Publishing.
	- Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG.
	- Vorlesungsskript.

Course L1077: Process Measurement Engineering		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	45 Minuten	
scale		
Lecturer	Prof. Roland Harig	
Language	DE/EN	
Cycle	SoSe	
Content	Process measurement engineering in the context of process control engineering	
	 Challenges of process measurement engineering 	
	 Instrumentation of processes 	
	 Classification of pickups 	
	Systems theory in process measurement engineering	
	 Generic linear description of pickups 	
	 Mathematical description of two-port systems 	
	Fourier and Laplace transformation	
	Correlational measurement	
	Wide band signals	
	 Auto- and cross-correlation function and their applications 	
	 Fault-free operation of correlational methods 	
	Transmission of analog and digital measurement signals	
	 Modulation process (amplitude and frequency modulation) 	
	• Multiplexing	
	 Analog to digital converter 	
Literature	- Färber: "Prozeßrechentechnik", Springer-Verlag 1994	
	- Kiencke, Kronmüller: "Meßtechnik", Springer Verlag Berlin Heidelberg, 1995	
	- A. Ambardar: "Analog and Digital Signal Processing" (1), PWS Publishing Company, 1995, NTC 339	
	- A. Papoulis: "Signal Analysis" (1), McGraw-Hill, 1987, NTC 312 (LB)	
	- M. Schwartz: "Information Transmission, Modulation and Noise" (3,4), McGraw-Hill, 1980, 2402095	
	- S. Haykin: "Communication Systems" (1,3), Wiley&Sons, 1983, 2419072	
	- H. Sheingold: "Analog-Digital Conversion Handbook" (5), Prentice-Hall, 1986, 2440072	
	- J. Fraden: "AIP Handbook of Modern Sensors" (5,6), American Institute of Physics, 1993, MTB 346	

Course L1083: Process Measurement Engineering	
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	
scale	
Lecturer	Prof. Roland Harig
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0664: Feedback Con	trol in Medical Technology
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	20 min
scale	
Lecturer	Johannes Kreuzer, Christian Neuhaus
Language	DE
Cycle	SoSe
Content	Always viewed from the engineer's point of view, the lecture is structured as follows: Introduction to the topic Fundamentals of physiological modelling Introduction to Breathing and Ventilation Physiology and Pathology in Cardiology Introduction to the Regulation of Blood Glucose kidney function and renal replacement therapy Representation of the control technology on the concrete ventilator Excursion to a medical technology company Techniques of modeling, simulation and controller development are discussed. In the models, simple equivalent block diagrams for physiological processes are derived and explained how sensors, controllers and actuators are operated. MATLAB and SIMULINK are used as development tools.
Literature	 Leonhardt, S., & Walter, M. (2016). Medizintechnische Systeme. Berlin, Heidelberg: Springer Vieweg. Werner, J. (2005). Kooperative und autonome Systeme der Medizintechnik. München: Oldenbourg. Oczenski, W. (2017). Atmen : Atemhilfen ; Atemphysiologie und Beatmungstechnik: Georg Thieme Verlag KG.

Course L1630: Applied Dyna	nics
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	SoSe
Content	 Modelling of Multibody Systems Basics from kinematics and kinetics Constraints Multibody systems in minimal coordinates State space, linearization and modal analysis Multibody systems with kinematic constraints Multibody systems as DAE Non-holonomic multibody systems Experimental Methods in Dynamics
Literature	Schiehlen, W.; Eberhard, P.: Technische Dynamik, 4. Auflage, Vieweg+Teubner: Wiesbaden, 2014. Woernle, C.: Mehrkörpersysteme, Springer: Heidelberg, 2011. Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.

Courses			
Гitle	Тур	Hrs/wk	СР
Applied Automation (L1592)	Project-/problem-based Learning	3	3
Ergonomics (L0653)	Lecture	2	3
Advanced Training Course SE-ZERT	(L2739) Project-/problem-based Learning	2	3
Development Management for Mec	hatronics (L1512) Lecture	2	3
atigue & Damage Tolerance (L031	0) Lecture	2	3
ndustry 4.0 for engineers (L2012)	Lecture	2	3
licrocontroller Circuits: Implement	ation in Hardware and Software (L0087) Seminar	2	2
licrosystems Technology (L0724)	Lecture	2	4
Iodel-Based Systems Engineering	(MBSE) with SysML/UML (L1551) Project-/problem-based Learning	3	3
Sustainable Industrial Production (L	2863) Lecture	2	3
Process Measurement Engineering	(L1077) Lecture	2	3
Process Measurement Engineering	(L1083) Recitation Section (large)	1	1
eedback Control in Medical Techn	ology (L0664) Lecture	2	3
Applied Dynamics (L1630)	Lecture	2	3
Module Responsible	NN		
Admission Requirements	None		
Recommended Previous	None		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	 Students are able to express their extended knowledge and discuss the connection of dif areas of mechatronics 	fferent specia	fields or applicat
	 Students are qualified to connect different special fields with each other 		
Skills			
Skills	Students can apply specialized solution strategies and new scientific methods in selected a	areas	
Skills	 Students can apply specialized solution strategies and new scientific methods in selected a Students are able to transfer learned skills to new and unknown problems and can develop 		approaches
			approaches
Personal Competence	Students are able to transfer learned skills to new and unknown problems and can develop		approaches
Personal Competence Social Competence	Students are able to transfer learned skills to new and unknown problems and can develop		approaches
Personal Competence	Students are able to transfer learned skills to new and unknown problems and can develop	p own solutior	approaches
Personal Competence Social Competence Autonomy	Students are able to transfer learned skills to new and unknown problems and can develop None	p own solutior	approaches
Personal Competence Social Competence Autonomy	 Students are able to transfer learned skills to new and unknown problems and can develop None Students are able to develop their knowledge and skills by autonomous election of courses Depends on choice of courses 	p own solutior	approaches
Personal Competence Social Competence Autonomy Workload in Hours Credit points	 Students are able to transfer learned skills to new and unknown problems and can develop None Students are able to develop their knowledge and skills by autonomous election of courses Depends on choice of courses 	p own solutior	approaches

Course L0653: Ergonomics	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Armin Bossemeyer
Language	DE
Cycle	WiSe
Content	
Literature	

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

Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 Minuten
scale	
Lecturer	NN, Dr. Johannes Nicolas Gebhardt
Language	DE
Cycle	SoSe
Content	 Processes and methods of product development - from idea to market launch identification of market and technology potentials development of a common product architecture Synchronized product development across all engineering disciplines product validation incl. customer view Steering and optimization of product development Design of processes for product development IT systems for product development Establishment of management standards Typical types of organization
Literature	 Bender: Embedded Systems - qualitätsorientierte Entwicklung Ehrlenspiel: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit Gausemeier/Ebbesmeyer/Kallmeyer: Produktinnovation - Strategische Planung und Entwicklung der Produkte von morger Haberfellner/de Weck/Fricke/Vössner: Systems Engineering: Grundlagen und Anwendung Lindemann: Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden Pahl/Beitz: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung. Methoden und Anwendung VDI-Richtlinie 2206: Entwicklungsmethodik für mechatronische Systeme

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

Course L2012: Industry 4.0 f	Course L2012: Industry 4.0 for engineers	
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	120 min	
scale		
Lecturer	Prof. Thorsten Schüppstuhl	
Language	DE	
Cycle	SoSe	
Content		
Literature		

Course L0087: Microcontrolle	er Circuits: Implementation in Hardware and Software
Тур	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and	10 min. Vortrag + anschließende Diskussion
scale	
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe/SoSe
Content	
Literature	ATmega16A 8-bit Microcontroller with 16K Bytes In-System Programmable Flash - DATASHEET, Atmel Corporation 2014
	Atmel AVR 8-bit Instruction Set Instruction Set Manual, Atmel Corporation 2016

Course L0724: Microsystems	Technology
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques: (hermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering: CVD techniques: APCVD, LECVD and LECVD: screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processe, dry etching: back sputtering, plasma etching, RIE, Bosch process, tory process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pi-100, spreading resistance sensor, np junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer) Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process) Magnetic Sensors (galvanomagnetic sensors: splining current Hall sensor and magneto-transistor; magnetoresistive sensor; corganic seniconductor gas sensors: pellistor and thermal conductivity sensor, metal oxide semiconductor gas sensor; pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor; pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensors; pellistor and thermal conductivity sensor; metal oxide semiconpump, di
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010 G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

Тур	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung
Examination duration and	ca. 10 Seiten
scale	
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

Тур	Lecture
Hrs/wk	
CP	3
	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur 60 min
scale	
	Dr. Simon Markus Kothe
Language	
Cycle	
-	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufactur
	processes that change the form and physical properties of raw materials. Manufacturing is a central driver of econo development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities resi in enormous global energy and material demands that are harmful to both the environment and people. Historically, indusi activities were mostly oriented towards economic constraints, while social and environmental consequences were only ha considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the nat regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. Thi emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Ear annual regenerative capacity.
	This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cyclo products. For this, the following topics will be highlighted:
	- Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance tomorrow's manufacturing;
	- raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for environmental impact of manufactured products;
	- Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy a resource efficiency;
	- Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps modeling (1), evaluating (2) and improving (3);
	- Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA);
	- Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product cycle assessment.
Literature	Literatur:
	- Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing.
	- Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Ch Springer International Publishing.
	- Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapo Springer.
	- Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer Internatic Publishing.
	- Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG.
	- Vorlesungsskript.

Course L1077: Process Meas	urement Engineering
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	45 Minuten
scale	
Lecturer	Prof. Roland Harig
Language	DE/EN
Cycle	SoSe
Content	 Process measurement engineering in the context of process control engineering
	 Challenges of process measurement engineering
	 Instrumentation of processes
	Classification of pickups
	Systems theory in process measurement engineering
	Generic linear description of pickups
	 Mathematical description of two-port systems
	Fourier and Laplace transformation
	Correlational measurement
	Wide band signals
	 Auto- and cross-correlation function and their applications
	 Fault-free operation of correlational methods
	Transmission of analog and digital measurement signals
	 Modulation process (amplitude and frequency modulation)
	• Multiplexing
	 Analog to digital converter
Literature	- Färber: "Prozeßrechentechnik", Springer-Verlag 1994
	- Kiencke, Kronmüller: "Meßtechnik", Springer Verlag Berlin Heidelberg, 1995
	- A. Ambardar: "Analog and Digital Signal Processing" (1), PWS Publishing Company, 1995, NTC 339
	- A. Papoulis: "Signal Analysis" (1), McGraw-Hill, 1987, NTC 312 (LB)
	- M. Schwartz: "Information Transmission, Modulation and Noise" (3,4), McGraw-Hill, 1980, 2402095
	- S. Haykin: "Communication Systems" (1,3), Wiley&Sons, 1983, 2419072
	- H. Sheingold: "Analog-Digital Conversion Handbook" (5), Prentice-Hall, 1986, 2440072
	- J. Fraden: "AIP Handbook of Modern Sensors" (5,6), American Institute of Physics, 1993, MTB 346
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Course L1083: Process Meas	urement Engineering
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	
scale	
Lecturer	Prof. Roland Harig
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0664: Feedback Con	trol in Medical Technology
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	20 min
scale	
Lecturer	Johannes Kreuzer, Christian Neuhaus
Language	DE
Cycle	SoSe
Content	Always viewed from the engineer's point of view, the lecture is structured as follows: Introduction to the topic Fundamentals of physiological modelling Introduction to Breathing and Ventilation Physiology and Pathology in Cardiology Introduction to the Regulation of Blood Glucose kidney function and renal replacement therapy Representation of the control technology on the concrete ventilator Excursion to a medical technology company Techniques of modeling, simulation and controller development are discussed. In the models, simple equivalent block diagrams for physiological processes are derived and explained how sensors, controllers and actuators are operated. MATLAB and SIMULINK are used as development tools.
Literature	 Leonhardt, S., & Walter, M. (2016). Medizintechnische Systeme. Berlin, Heidelberg: Springer Vieweg. Werner, J. (2005). Kooperative und autonome Systeme der Medizintechnik. München: Oldenbourg. Oczenski, W. (2017). Atmen : Atemhilfen ; Atemphysiologie und Beatmungstechnik: Georg Thieme Verlag KG.

Course L1630: Applied Dyna	mics
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	SoSe
Content	 Modelling of Multibody Systems Basics from kinematics and kinetics Constraints Multibody systems in minimal coordinates State space, linearization and modal analysis Multibody systems with kinematic constraints Multibody systems as DAE Non-holonomic multibody systems Experimental Methods in Dynamics
Literature	Schiehlen, W.; Eberhard, P.: Technische Dynamik, 4. Auflage, Vieweg+Teubner: Wiesbaden, 2014. Woernle, C.: Mehrkörpersysteme, Springer: Heidelberg, 2011. Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.

Module M1306: Conti	rol Lab C				
Courses					
Fitle		Тур	Hrs/wk	СР	
Control Lab IX (L1836)		Practical Course	1	1	
Control Lab VII (L1834)		Practical Course	1	1	
Control Lab VIII (L1835)		Practical Course	1	1	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	Chata and a matheda				
Knowledge					
	LQG control				
	H2 and H-infinity optimal control				
	 uncertain plant models and robus 	st control			
	LPV control				
Educational Objectives	After taking part successfully, students	have reached the following learning results			
Professional Competence					
Knowledge					
	Students can explain the differen	ce between validation of a control lop in simulati	on and experimental v	alidation	
Skills					
	Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify				
	dynamic model that can be used	for controller synthesis			
	 They are capable of using stand 	dard software tools (Matlab Control Toolbox) fo	r the design and imp	lementation of L	
	controllers				
	 They are capable of using standard 	ard software tools (Matlab Robust Control Toolbo>	c) for the mixed-sensit	ivity design and	
	implementation of H-infinity optim	nal controllers			
	They are capable of representing	model uncertainty, and of designing and implem	nenting a robust contro	oller	
	• They are capable of using standa	rd software tools (Matlab Robust Control Toolbox) for the design and th	e implementatior	
	LPV gain-scheduled controllers				
Demonstration of the second second					
Personal Competence					
Social Competence	 Students can work in teams to co 	onduct experiments and document the results			
Autonomy	 Students can independently carry 	y out simulation studies to design and validate co	ntrol loops		
	· Students can independently carry				
Workload in Hours	Independent Study Time 48, Study Time	e in Lecture 42			
Credit points	3				
Course achievement	None				
Examination	Written elaboration				
Examination duration and	1				
scale					
Assignment for the	Electrical Engineering: Specialisation Co	ontrol and Power Systems Engineering: Elective C	ompulsory		
Following Curricula	Mechatronics: Specialisation Intelligent	Systems and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System De	sign: Elective Compulsory			
	Theoretical Machanical Engineering, Co.	re Qualification: Elective Compulsory			

Course 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, Adwait Datar, Patrick Göttsch
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

Course L1834: Control Lab V	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
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

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

Module M1269: Lab C	yber-Physical Systems			
^				
Courses				
Title Lab Cyber-Physical Systems (L1740)) Project-/prol	olem-based Learning	Hrs/wk 4	CP 6
Module Responsible	Prof. Heiko Falk			
Admission Requirements	None			
Recommended Previous	Module "Embedded Systems"			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning i	results		
Professional Competence	······································			
-	Cyber-Physical Systems (CPS) are tightly integrated with their surrounding e	environment via sens	ors A/D and	D/A converters
Kilowieuge	actors. Due to their particular application areas, highly specialized sensors,			
	is a large variety of different specification approaches for CPS - in contrast to			
	is a large valiety of different specification approaches for cr 3 - in contrast to		ignicering up	proderies.
	Based on practical experiments using robot kits and computers, the basics	of specification and	modelling of	CPS are taught.
	lab introduces into the area (basic notions, characteristical properties) and $\frac{1}{2}$	their specification teo	chniques (mo	dels of computat
	hierarchical automata, data flow models, petri nets, imperative approaches)	. Since CPS frequent	ly perform co	ontrol tasks, the la
	experiments will base on simple control applications. The experiments	will use state-of-the-	art industria	l specification to
	(MATLAB/Simulink, LabVIEW, NXC) in order to model cyber-physical models	s that interact with t	he environm	ent via sensors a
	actors.			
Skills	After successful attendance of the lab, students are able to develop simple C	PS. They understand	the interdep	endencies betwe
	CPS and its surrounding processes which stem from the fact that a CPS inter	acts with the environ	ment via sen	sors, A/D convert
	digital processors, D/A converters and actors. The lab enables students	to compare modellir	ng approache	es, to evaluate t
	advantages and limitations, and to decide which technique to use for a cond	crete task. They will h	be able to ap	ply these techniq
	to practical problems. They obtain first experiences in hardware-related so	ftware development,	in industry-r	elevant specifica
	tools and in the area of simple control applications.			
Personal Competence				
Social Competence	Students are able to solve similar problems alone or in a group and to preser	nt the results accordin	ngly.	
Autonomy	Students are able to acquire new knowledge from specific literature and to a	ssociate this knowled	lge with othe	r classes.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	Execution and documentation of all lab experiments			
scale				
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation	Computer Science: El	ective Comp	ulsory
Following Curricula	Computer Science: Specialisation II. Mathematics and Engineering Science: E	Elective Compulsory		
	Computer Science: Specialisation Computer and Software Engineering: Elect	ive Compulsory		
	General Engineering Science (English program, 7 semester): Specialisation C	Computer Science: Ele	ective Compu	lsory
	Computational Science and Engineering: Specialisation II. Mathematics & En	gineering Science: Ele	ective Compu	llsory
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Comp	oulsory		
	Mechatronics: Specialisation System Design: Elective Compulsory			
	Mechatronics: Technical Complementary Course: Elective Compulsory			

Course L1740: Lab Cyber-Phy	ysical Systems
Тур	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Heiko Falk
Language	DE/EN
Cycle	SoSe
Content	 Experiment 1: Programming in NXC Experiment 2: Programming the Robot in Matlab/Simulink Experiment 3: Programming the Robot in LabVIEW
Literature	 Peter Marwedel. Embedded System Design - Embedded System Foundations of Cyber-Physical Systems. 2 nd Edition, Springer, 2012. Begleitende Foliensätze

Courses				
Title		Тур	Hrs/wk	СР
Advanced Topics in Vibration (L174	3)	Project-/problem-based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Vibration Theory			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fol	lowing learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts of Advan	ced Vibrations and to develop and resea	arch new terms	and concepts.
Skills	Students are able to apply existing methods and procesures of Ad	vanced Vibrations and to develop novel	methods and p	procedures.
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks individually a	nd to identify and follow up novel resear	ch tasks by the	emselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Mechatronics: Specialisation System Design: Elective Compu	Ilsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotic	s: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective Co	mpulsory		
	Theoretical Mechanical Engineering: Specialisation Product E	ovelopment and Braduction, Electiv	o Compulsory	

Course L1/43: Advanced Topics in Vibration	
Тур	Project-/problem-based Learning
Hrs/wk	4
СР	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann, Merten Tiedemann, Sebastian Kruse
Language	DE/EN
Cycle	SoSe
Content	Research Topics in Vibrations.
Literature	Aktuelle Veröffentlichungen

Courses				
Title		Tree		СР
Humanoid Robotics (L0663)		Typ Seminar	Hrs/wk 2	2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge				
	Introduction to control systems			
	 Control theory and design 			
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge	- Chudonka con ovaloin humonoid vohoto			
	Students can explain humanoid robots.	onto for different tools in humanaid r	hatiaa	
	 Students learn to apply basic control conc 	epts for different tasks in numanoid fo	obotics.	
Skills				
	 Students acquire knowledge about selected 		d on specified literature	
	Students generalize developed results and			
	 Students practice to prepare and give a p 	resentation		
Personal Competence				
Social Competence				
	Students are capable of developing solution			
	 They are able to provide appropriate feed 	back and handle constructive criticism	n of their own results	
Autonomy				
	 Students evaluate advantages and draw 	backs of different forms of presenta	ation for specific tasks	and select the be
	solution		and fallow and a station	
	 Students familiarize themselves with a s such that a scientific discussion develops 	clentific field, are able of introduce it	and follow presentation	ns of other studen
	such that a scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lectu	ire 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
-	Mechatronics: Specialisation Intelligent Systems			
Following Curricula	Mechatronics: Specialisation System Design: Ele			
	Biomedical Engineering: Specialisation Artificial			
	Biomedical Engineering: Specialisation Implants			
	Biomedical Engineering: Specialisation Medical T			
	Biomedical Engineering: Specialisation Managen Theoretical Mechanical Engineering: Specialisati			

Course L0663: Humanoid Ro	botics
Тур	Seminar
Hrs/wk	2
CP	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).

	Тур	Hrs/wk	СР
ïcation (L0660)	Lecture	2	3
Prof. Herbert Werner			
None			
	· · · · · · · · · · · · · · · · · · ·		
	onse, root locus)		
Basic knowledge about stochasti	c processes		
After taking part successfully, students	have reached the following learning results		
• Students can explain the gener	al framework of the prediction error method :	and its application to a	variaty of linear
		and its application to a	variety of fiftear a
	nercentron networks are used to model nonlin	ear dynamics	
		-	als
	•		
		canoación cheory	
 Students are capable of applying 	as the predicition error method to the experi	montal identification of	linear and poplin
	ig the prediction error method to the expens		
	a a poplinear predictive control scheme based	on a neural network m	laho
they can do the above using sta			
Students can work in mixed groups on	specific problems to arrive at joint solutions.		
Students are able to find required infor	mation in sources provided (lecture notes, liter	ature, software docume	entation) and use i
	······································		
	e in Lecture 28		
5			
Oral exam			
30 min			
Electrical Engineering: Specialisation Co	ontrol and Power Systems Engineering: Elective	2 Compulsory	
Biomedical Engineering: Specialisation	Implants and Endoprostheses: Elective Compul	sory	
Biomedical Engineering: Specialisation	Medical Technology and Control Theory: Comp		
Biomedical Engineering: Specialisation	Medical Technology and Control Theory: Comp Management and Business Administration: Elec		
	 State space methods Discrete-time systems Linear algebra, singular value de Basic knowledge about stochasti After taking part successfully, students Students can explain the gener nonlinear model structures They can explain how multilayer They can explain how multilayer They can explain how an approx They can explain the idea of sub Students are capable of applyin models for dynamic systems They are capable of applying sut They are capable of applying sut They can do the above using sta Students are able to find required infor solve given problems. Independent Study Time 62, Study Tim 3 None Oral exam 30 min Electrical Engineering: Specialisation Comection of the study state of the s	fication (L0660) Lecture Prof. Herbert Werner None Classical control (frequency response, root locus) State space methods Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic processes After taking part successfully, students have reached the following learning results Students can explain the general framework of the prediction error method a nonlinear model structures They can explain how multilayer perceptron networks are used to model nonline They can explain how an approximate predictive control scheme can be based They can explain the idea of subspace identification and its relation to Kalman r Students are capable of applying the predicition error method to the experim models for dynamic systems They are capable of applying subspace algorithms to the experimental identific: They can do the above using standard software tools (including the Matlab Syst Students are able to find required information in sources provided (lecture notes, liter solve given problems. Independent Study Time 62, Study Time in Lecture 28 3 None Oral exam 30 min Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Mechatronics: Specialisation System Design: Elective Compulsory	fication (L0660) Lecture 2 Prof. Herbert Werner None Classical control (frequency response, root locus) State space methods Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic processes After taking part successfully, students have reached the following learning results Students can explain the general framework of the prediction error method and its application to a nonlinear model structures Students 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 mode They can explain the idea of subspace identification and its relation to kalman realisation theory Students are capable of applying the prediction error method to the experimental identification of models for dynamic systems They are capable of applying subspace algorithms to the experimental identification of linear models for they are capable of applying subspace algorithms to the experimental identification Toolbo Students can work in mixed groups on specific problems to arrive at joint solutions. Students are able to find required information in sources provided (lecture notes, literature, software docume solve given problems. Independent Study Time 62, Study Time in Lecture 28 3 None Oral exam 30 min Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory

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

Module M0939: Contr	ol Lab A			
Courses				
Title		Тур	Hrs/wk	СР
Control Lab I (L1093)		Practical Course	1	1
Control Lab II (L1291)		Practical Course	1	1
Control Lab III (L1665)		Practical Course	1	1
Control Lab IV (L1666)		Practical Course	1	1
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	 State space methods 			
	LQG control			
	 H2 and H-infinity optimal control 			
	 uncertain plant models and robust c 	control		
	LPV control			
Educational Objectives	After taking part successfully, students have	ve reached the following learning results		
Professional Competence	Arter taking part successionly, students na	reached the following learning results		
Knowledge				
Kilowieuge	• Students can explain the difference	between validation of a control lop in simulation	on and experimental v	validation
Skills				
SKIIIS	 Students are capable of applying 	basic system identification tools (Matlab Sys	tem Identification To	olbox) to identify
	dynamic model that can be used for	controller synthesis		
		d software tools (Matlab Control Toolbox) for	the design and imp	plementation of LC
	controllers			
		software tools (Matlab Robust Control Toolbox)) for the mixed-sensit	tivity design and th
	implementation of H-infinity optimal		, for the mixed sensi	acoign and a
			opting a robust contr	allar
		odel uncertainty, and of designing and implement		
		software tools (Matlab Robust Control Toolbox)	for the design and tr	ie implementation
	LPV gain-scheduled controllers			
Personal Competence				
Social Competence				
	 Students can work in teams to cond 	uct experiments and document the results		
Autonomy				
Autonomy	Students can independently carry or	ut simulation studies to design and validate cor	ntrol loops	
Workload in Hours	Independent Study Time 64, Study Time in	Lecture 56		
Credit points	4			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	1			
scale				
Assignment for the	Electrical Engineering: Specialisation Contr	rol and Power Systems Engineering: Elective Co	ompulsory	
Following Curricula	Mechatronics: Specialisation System Desig	n: Elective Compulsory		
-	Mechatronics: Specialisation Intelligent Sys			
		alisation Robotics and Computer Science: Elect	ive Compulsorv	
		the second		

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

Module Manual M.Sc. "Mechatronics"

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

ourse L1665: Control Lab III		
Practical Course		
1		
1		
Independent Study Time 16, Study Time in Lecture 14		
Prof. Herbert Werner, Adwait Datar, Patrick Göttsch		
EN		
WiSe/SoSe		
One of the offered experiments in control theory.		
Experiment Guides		

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

Courses					
Title			Тур	Hrs/wk	СР
Software for Embdedded Systems	L1069)		Lecture	2	3
Software for Embdedded Systems	L1070)		Recitation Section (small)	3	3
Module Responsible	Prof. Bernd-Christian Renner				
Admission Requirements	None				
Recommended Previous					
Knowledge	 Good knowledge and e 		g language C		
	 Basis knowledge in sof 	5 5			
	 Basic understanding of 	assembly language			
Educational Objectives	After taking part successfully,	students have reached t	ne following learning results		
Professional Competence					
Knowledge	Students know the basic prin	ciples and procedures of	software engineering for embedded s	ystems. They are	able to describe
2	Students know the basic principles and procedures of software engineering for embedded systems. They are able to describe usage and pros of event based programming using interrupts. They know the components and functions of a com-				
			of real time systems. They know at		
	real time operating systems in				
Skills Students build interrupt-based programs for a concrete microcontroller. They build and use a preempt			se a preemptive	scheduler They i	
SKiis	peripheral components (timer, ADC, EEPROM) to realize complex tasks for embedded systems. To interfac			-	
	components they utilize seria			Systems. to inte	indee with exter
Personal Competence	components they attile seria	prococolor			
Social Competence					
Autonomy					
· · · · · · · · · · · · · · · · · · ·	Independent Study Time 110,	Study Time in Lecture 7(
Credit points		Study fille in Lecture 70	·		
Course achievement		Des	ription		
course demotement	No 10 % Attest	ation			
Examination	Written exam				
Examination duration and	90 min				
scale					
Assignment for the	Computer Science: Specialisa	tion I. Computer and Soft	ware Engineering: Elective Compulsory	/	
Following Curricula	Electrical Engineering: Specia	lisation Information and O	communication Systems: Elective Com	pulsory	
-			n Communication Systems, Focus Soft		ompulsory
	Mechatronics: Technical Com	· ·			
	Mechatronics: Specialisation I	-			
	Mechatronics: Specialisation S				

Course L1069: Software for I	Embdedded 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	DE/EN
Cycle	SoSe
Content	 General-Purpose Processors Programming the Atmel AVR Interrupts C for Embedded Systems Standard Single Purpose Processors: Peripherals Finite-State Machines Memory Operating Systems for Embedded Systems Real-Time Embedded Systems Boot loader and Power Management
Literature	 Embedded System Design, F. Vahid and T. Givargis, John Wiley Programming Embedded Systems: With C and Gnu Development Tools, M. Barr and A. Massa, O'Reilly C und C++ für Embedded Systems, F. Bollow, M. Homann, K. Köhn, MITP The Art of Designing Embedded Systems, J. Ganssle, Newnses Mikrocomputertechnik mit Controllern der Atmel AVR-RISC-Familie, G. Schmitt, Oldenbourg Making Embedded Systems: Design Patterns for Great Software, E. White, O'Reilly

Course L1070: Software for I	rse L1070: Software for Embdedded Systems				
Тур	Recitation Section (small)				
Hrs/wk	3				
CP	3				
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42				
Lecturer	Prof. Bernd-Christian Renner				
Language	DE/EN				
Cycle	SoSe				
Content	See interlocking course				
Literature	See interlocking course				

Courses							
Fitle		Тур	Hrs/wk	СР			
Compilers for Embedded Systems (L1692)	Lecture	3	4			
Compilers for Embedded Systems (L1693)	Project-/problem-based Learn	ing 1	2			
Module Responsible	Prof. Heiko Falk						
Admission Requirements	None						
Recommended Previous	Module "Embedded Systems"						
Knowledge	C/C++ Programming skills						
Educational Objectives	After taking part successfully, students h	ave reached the following learning results					
Professional Competence							
Knowledge	The relevance of embedded systems increases from year to year. Within such systems, the amount of software to be execute embedded processors grows continuously due to its lower costs and higher flexibility. Because of the particular application a of embedded systems, highly optimized and application-specific processors are deployed. Such highly specialized proces impose high demands on compilers which have to generate code of highest quality. After the successful attendance of this con 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 lead particular, • which kinds of optimizations are applicable at the source code level, • how the translation from source code to assembly code is performed, • which kinds of optimizations are applicable at the assembly code level, • how register allocation is performed, and • how memory hierarchies can be exploited effectively.						
Skills	energy dissipation, code size), the studer	often have to optimize for multiple objectives (e.g., nts learn to evaluate the influence of optimizations e, students shall be able to translate high-level prog	on these different	criteria.			
	be enabled to assess which kind of code optimization should be applied most effectively at which abstraction level (e.g., sou assembly code) within a compiler. While attending the labs, the students will learn to implement a fully functional compiler including optimizations.						
Personal Competence							
	Students are able to solve similar problem	ms alone or in a group and to present the results ac	cordingly.				
Autonomy	Students are able to acquire new knowle	dge from specific literature and to associate this kn	owledge with othe	er classes.			
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56					
Credit points	6						
Course achievement	None						
Examination	Oral exam						
Examination duration and	30 min						
scale							
Assignment for the	Computer Science: Specialisation I. Comp	puter and Software Engineering: Elective Compulsor	У				
Following Curricula	Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory						
	Aircraft Systems Engineering: Core Qualification: Elective Compulsory						
	Mechatronics: Specialisation Intelligent S	systems and Robotics: Elective Compulsory					
		ign: Elective Compulsory					

urse L1692: Compilers for	Embedded Systems				
Тур	Lecture				
Hrs/wk	3				
CP	4				
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42				
Lecturer	Prof. Heiko Falk				
Language	DE/EN				
Cycle	SoSe				
Content	 Introduction and Motivation Compilers for Embedded Systems - Requirements and Dependencies Internal Structure of Compilers Pre-Pass Optimizations HIR Optimizations and Transformations Code Generation LIR Optimizations and Transformations Register Allocation WCET-Aware Compilation Outlook 				
Literature					

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

Courses					
Courses					
Title		Тур	Hrs/wk	СР	
Optimal and Robust Control (L0658 Optimal and Robust Control (L0659		Lecture Recitation Section (small)	2	3	
Module Responsible			-	5	
-					
Admission Requirements	None				
Recommended Previous Knowledge	Classical control (frequency response, root locus)				
Kilowieuge	State space methods				
	Linear algebra, singular value decomposition				
Educational Objectives	After taking part successfully, students have reached the	following loarning rosults			
Professional Competence	Arter taking part successiony, students have reached the	following learning results			
Knowledge					
Knowledge	Students can explain the significance of the matrix	Riccati equation for the solution of I	LQ problems.		
	They can explain the duality between optimal stat	e feedback and optimal state estima	tion.		
	 They can explain how the H2 and H-infinity norms 	are used to represent stability and p	erformance cons	traints.	
	 They can explain how an LQG design problem can 				
	They can explain how model uncertainty can be r				
	They can explain how - based on the small gain t	heorem - a robust controller can gu	arantee stability	and performance	
	an uncertain plant.They understand how analysis and synthesis cond	tions on foodback loops can be repr	sonted as linear	matrix inequalitie	
	They understand now analysis and synthesis cond	tions on reedback loops can be repre	esenteu as imeai	macrix mequalitie	
Skills	Chudente en estable of desiration and turing LOC				
	Students are capable of designing and tuning LQG They are capable of representing a U2 or U infinite			nd of using shand	
	 They are capable of representing a H2 or H-infinit software tools for solving it. 	design problem in the form of a gel	neralized plant, a	ind of using stand	
	 They are capable of translating time and frequer 	cy domain specifications for control	loops into const	raints on closed-l	
	sensitivity functions, and of carrying out a mixed-s				
	They are capable of constructing an LFT uncerta		, and of designin	ng a mixed-object	
	robust controller.	,	,	.9	
	 They are capable of formulating analysis and syn 	hesis conditions as linear matrix ine	qualities (LMI), a	nd of using standa	
	LMI-solvers for solving them.				
	They can carry out all of the above using standard	software tools (Matlab robust contro	l toolbox).		
Demonstration of the second					
Personal Competence	Chudente con work in small groups on specific problems t	e envire et icint colutions			
	Students can work in small groups on specific problems to arrive at joint solutions. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use				
Autonomy	solve given problems.	provided (lecture notes, literature, s	ortware docume	ntation) and use it	
	solve given problems.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Course achievement					
Examination					
Examination duration and					
scale	30 1111				
56416					
-	Electrical Engineering: Specialisation Control and Power	systems Engineering: Elective Compu	ulsory		
Following Curricula	Energy Systems: Core Qualification: Elective Compulsory				
	Aircraft Systems Engineering: Core Qualification: Elective				
	Mechatronics: Specialisation Intelligent Systems and Rob				
	Mechatronics: Specialisation System Design: Elective Col		Compulsor		
	Biomedical Engineering: Specialisation Artificial Organs a	-	Lompulsory		
	Biomedical Engineering: Specialisation Implants and End Biomedical Engineering: Specialisation Medical Technolo		oulsony		
	Biomedical Engineering: Specialisation Medical Technolo Biomedical Engineering: Specialisation Management and		-		
	Product Development, Materials and Production: Speciali				
	Product Development, Materials and Production: Speciali				
	Product Development, Materials and Production: Speciali		-		
	Theoretical Mechanical Engineering: Core Qualification: E				

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

Course L0659: Optimal and F	ourse L0659: Optimal and Robust Control			
Тур	Recitation Section (small)			
Hrs/wk	2			
СР				
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28			
Lecturer	of. Herbert Werner			
Language	N			
Cycle	SoSe			
Content	ee interlocking course			
Literature	e interlocking course			

Module M1400: Desig						
Courses						
Title			Тур	Hrs/wl	CP	
Designing Dependable Systems (L2	2000)		Lecture	2	3	
Designing Dependable Systems (L2	2001)		Recitation Section	on (small) 2	3	
Module Responsible	Prof. Görschwin Fey					
Admission Requirements	None					
Recommended Previous	Basic knowledge about	data structures and alg	jorithms			
Knowledge						
Educational Objectives	After taking part succe	ssfully, students have r	eached the following learning resu	lts		
Professional Competence						
Knowledge	In the following "depen	dable" summarizes the	concepts Reliability, Availability, N	laintainability, Safety and	d Security.	
	Knowledge shout appr	aachac far dacigning da	pendable systems, e.g.,			
	Knowledge about appro	baches for designing de	pendable systems, e.g.,			
	Structural solution	ons like modular redund	ancy			
	 Algorithmic solution 	tions like handling byza	ntine faults or checkpointing			
	Knowledge about meth	ods for the analysis of o	enendable systems			
	Knowledge about meth		iependable systems			
Skills	Ability to implement de	nendable systems usin	the above approaches			
JKIIIS	S Ability to implement dependable systems using the above approaches.					
	Ability to analyzs the dependability of systems using the above methods for analysis.					
Personal Competence						
Social Competence	Students					
Social competence	Statents					
	discuss relevant topics in class and					
	 present their sol 	utions orally.				
Autonomy	Using accompanying r	material students inder	endently learn in-depth relations	between concepts exp	lained in the lecture a	
		Using accompanying material students independently learn in-depth relations between concepts explained in the lecture an additional solution strategies.				
Workload in Hours		ne 124, Study Time in Le	ecture 56			
Credit points	6	· · · · · · · · · · · ·				
Course achievement	Compulsory Bonus	Form	Description			
ees. se demovement	Yes None	Subject theoretical	andDie Lösung einer Aufgabe is	t Zuslassungsvoraussetz	zung für die Prüfung.	
		practical work	Aufgabe wird in Vorlesung un	d Übung definiert.		
Examination	Oral exam					
Examination duration and	30 min					
scale						
Assignment for the	Computer Science: Spe	cialisation I. Computer	and Software Engineering: Elective	e Compulsory		
Following Curricula	Computational Science	and Engineering: Spec	alisation I. Computer Science: Elec	ctive Compulsory		
	Information and Comm	unication Systems: Spe	cialisation Secure and Dependable	IT Systems: Elective Cor	mpulsory	
	Mechatronics: Specialis	sation System Design: E	lective Compulsory			
	Microelectronics and M	icrosystems: Specialisa	ion Embedded Systems: Elective	Compulsory		

Course L2000: Designing Dep	pendable Systems
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Görschwin Fey
Language	DE/EN
Cycle	SoSe
Content	Description
	The term dependability comprises various aspects of a system. These are typically:
	 Reliability Availability Availability Maintainability Safety Security This makes dependability a core aspect that has to be considered early in system design, no matter whether software, embedded systems or full scale cyber-physical systems are considered.
	Contents The module introduces the basic concepts for the design and the analysis of dependable systems. Design examples for getting practical hands-on-experience in dependable design techniques. The module focuses towards embedded systems. The following topics are covered:
	 Modelling Fault Tolerance Design Concepts Analysis Techniques
Literature	

ourse L2001: Designing Dependable Systems				
Тур	ecitation Section (small)			
Hrs/wk	2			
CP	3			
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28			
Lecturer	of. Görschwin Fey			
Language	DE/EN			
Cycle	SoSe			
Content	ee interlocking course			
Literature	ee interlocking course			

Module M0565: Mech	atronic Syste	ms					
Courses							
Title					Тур	Hrs/wk	СР
Electro- and Contromechanics (L01	74)				Lecture 2		
Electro- and Contromechanics (L13	00)				Recitation Section (small)	1	2
Mechatronics Laboratory (L0196)					Project-/problem-based Learning	2	2
Module Responsible	NN						
Admission Requirements	None						
Recommended Previous	Fundamentals of m	nechanics, ele	ctromechanics	and control theo	bry		
Knowledge							
Educational Objectives	After taking part su	uccessfully, st	udents have r	eached the follow	ing learning results		
Professional Competence							
Knowledge	Students are able	to describe r	methods and o	alculations to de	sign, model, simulate and optin	nize mechatro	nic systems and c
2	repeat methods to				5 • • •		,
Skills	Students are able	to plan and	execute mech	atronic experime	ents. Students are able to mode	l mechatronic	systems and der
	simulations and op						.,
Personal Competence							
•	Students are able	to work goal-	oriented in sm	all mixed groups.	, learning and broadening teamw	ork abilities a	nd define task with
	the team.	·· · · · · · · · · · · · · · · · · ·			· · · · · · · · · · · · · · · · · · ·		
Autonomy	Students are able	o solve indivi	dually exercise	es related to this	lecture with instructional direction	n.	
	Students are able to plan, execute and summarize a mechatronic experiment.						
	Students are able	o pian, exect			iic experiment.		
Workload in Hours	Independent Study	Time 110, S	tudy Time in Le	ecture 70			
Credit points	6						
Course achievement	Compulsory Bonus	Form		Description			
	Yes None	Subject	theoretical	and			
		practical	work				
Examination	Written exam						
Examination duration and	90 min						
scale							
Assignment for the	Mechatronics: Spe	cialisation Int	elligent Systen	ns and Robotics: I	Elective Compulsory		
Fallsuda a Constants	Mechatronics: Specialisation System Design: Elective Compulsory						

Course L0174: Electro- and Contromechanics					
Тур	Lecture				
Hrs/wk	2				
CP	2				
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28				
Lecturer	NN				
Language	EN				
Cycle	SoSe				
Content	Introduction to methodical design of mechatronic systems:				
	 Modelling System identification Simulation Optimization 				
Literature	Denny Miu: Mechatronics, Springer 1992				
	Rolf Isermann: Mechatronic systems : fundamentals, Springer 2003				

Course L1300: Electro- and C	ourse L1300: Electro- and Contromechanics		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	NN		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L0196: Mechatronics	Laboratory	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	NN	
Language	DE/EN	
Cycle	SoSe	
Content	Modeling in MATLAB [®] und Simulink [®]	
	Controller Design (Linear, Nonlinear, Observer)	
	Parameter identification	
	Control of a real system with a realtimeboard and Simulink $^{\textcircled{B}}$ RTW	
Literature	- Abhängig vom Versuchsaufbau	
	- Depends on the experiment	

Courses						
Title		True	Line (mile	CP.		
	nos and Electromagnetic Compatibility (11660)	Typ Lecture	Hrs/wk	CP 4		
-	nas, and Electromagnetic Compatibility (L1669) nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	3 2	2		
	Prof. Christian Schuster	Recitation Section (smail)	2	2		
Admission Requirements						
Recommended Previous Knowledge	basic principles of physics and electrical engineering					
-	After taking part successfully, students have reached t	o following loorning results				
Professional Competence	Arter taking part successiony, students have reached t	le following learning results				
•	Students can explain the basic principles, relationship Electromagnetic Compatibility. Specific topics are: - Fundamental properties and phenomena of electrical		veguides and an	tennas as well as		
	- Steady-state sinusoidal analysis of electrical circuits					
	- Fundamental properties and phenomena of electroma	gnetic fields and waves				
	- Steady-state sinusoidal description of electromagneti					
	- Useful microwave network parameters					
	- Transmission lines and basic results from transmission line theory					
	- Plane wave propagation, superposition, reflection and refraction					
	- General theory of waveguides					
	 Most important types of waveguides and their proper 	ies				
	- Radiation and basic antenna parameters					
	- Most important types of antennas and their properties					
	- Numerical techniques and CAD tools for waveguide a	nd antenna design				
	- Fundamentals of Electromagnetic Compatibility					
	- Coupling mechanisms and countermeasures					
	- Shielding, grounding, filtering					
	- Standards and regulations					
	- EMC measurement techniques					
Skills	Students know how to apply various methods and me	dale for characterization and choice o	f wayaguidas an	d antonnas Thou		
SKIIIS	Students know how to apply various methods and mo					
	able to assess and qualify their basic electromagn Electromagnetic Compatibilty to the development of el		its and strategie	es from the field		
Personal Competence						
Social Competence	Students are able to work together on subject related English (e.g. during small group exercises).	tasks in small groups. They are able	to present their	results effectively		
Autonomy	Students are capable to gather information from su	ject related, professional publication	s and relate tha	it information to t		
	context of the lecture. They are able to make a conne					
	other lectures (e.g. theory of electromagnetic fields, f	indamentals of electrical engineering	/ physics). They o	can discuss techni		
	problems and physical effects in English.					
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70					
Credit points	6					
Course achievement	None					
Examination	Oral exam					
Examination duration and	45 min					
scale						
	General Engineering Science (German program, 7 sem	ester): Specialisation Electrical Engine	ering: Elective Co	mpulsory		
5	Electrical Engineering: Core Qualification: Elective Corr		5			
	Aircraft Systems Engineering: Core Qualification: Elective Corr					
	Mechatronics: Specialisation System Design: Elective C					

	Course L1669: Introduction t	o Waveguides, Antennas, and Electromagnetic Compatibility
CP 4 Workload in Hours Independent Study Time 78, Study Time in Lecture 42 Lecturer Prof. Christian Schuster Language DE/EN Cycte 555 Content This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high freque / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagat and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, syueproposition, reflection and refraction - General theory of waveguides and their properties - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Numerical techniques and CAD tools for waveguide and antenna design - Fundamental progradiums - Steady-state techniques and their properties - Steady-state techniques and their properties - Radiatis of Elect	Тур	Lecture
Workload in Hours Independent Study Time 78, Study Time in Lecture 42. Lecture Prof. Christian Schuster Cycle ScSe Content This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well Electromagnetic Compatibility (EM). It will be useful for engineers that face the technical challenge of transmitting high frequence / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagat and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal analysis of electromagnetic fields and waves - Steady-state sinusoidal analysis of electromagnetic fields and waves - Steady-state sinusoidal analysis of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides and their properties - Most important types of intermess and their properties - Radiation and basic anterna parameters - Most important types of antermass and their properties - Sinelding, grounding, fittering - Sinelafing, grounding, fittering - Sinelafing, grounding, fittering		3
Lecture Prof. Christian Schuster Language DE/EN Content This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequee / high bandwitch data in e.g. medical, automotive, or avoine applications. Both circuit and field concepts of wave propagat and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal description of electronagnetic fields and waves - Steady-state sinusoidal description of electronagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Bane wave propagation, superposition, reflection and refraction - General theory of waveguides - Nost important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamental orgunations - EMC measurement techniques - Sheiding, grounding, filtering - Stady-state sinusoidal angles between set in the properties - Radiation and basic results from transmission line theory - Bane wave propagation, Superposition, reflection and refraction <t< th=""><th>CP</th><th>4</th></t<>	CP	4
Language DE/EN Content This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high freque / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagat and Electromagnetic Compatibility will be introduced and discussed. Topics: - - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides and their properties - Radiation and basic anterna parameters - Most important types of antennas and their properties - Radiation and basic anterna parameters - Steiding, motioning, filtering - Steiding and basic anterna parameters - Most important types of maxenguetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations	Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Cycle SoSe Content This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high freque / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagat and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electronagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation. superposition, reflection and refraction - General theory of waveguides - Most important types of antennas and their properties - Radiation and basic antenna parameters - Most important types of antennas and countermeasures - Numerical techniques and Color for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and reguilations		
Content This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequee / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagat and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and neuromesures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques - Literature - Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)	Language	DE/EN
Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high freques / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagat and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamental of Electromagnetic Compatibility - Coupling mechanisms and ountermeasures - Standards and regulations - Bude metal conding, filtering - Standards and regulations - Bude metal condingues - Shedding, grounding, filtering - Standards and regulations<	Cycle	SoSe
 J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) D. M. Pozar, "Microwave Engineering", Wiley (2011) Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) 		This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal analysis of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of averguides and their properties - Radiation and basic antenna parameters - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations
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- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)		- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)
		- D. M. Pozar, "Microwave Engineering", Wiley (2011)
- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)		- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
		- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)
- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)		- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

Course L1877: Introduction t	ourse L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility		
Тур	Recitation Section (small)		
Hrs/wk	2		
CP	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Christian Schuster		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title		Тур	Hrs/wk	СР
Machine Learning and Data Mining	(L0340)	Lecture	2	4
Machine Learning and Data Mining	(L0510)	Recitation Section (small)	2	2
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusStochastics			
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Skills	can be improved by ensemble learning, reinforcement learning can also be expla Student derive decision trees and, in tu explain basic optimization techniques. T BME, MAP, ML, and EM algorithms for le know how to carry out Gaussian mixt machines, and name their basic applica and explain the basic components of t	rees and, in turn, propositional rule sets from simple and static data tables and are able to name an in techniques. They present and apply the basic idea of first-order inductive leaning. Students apply to gorithms for learning parameters of Bayesian networks and compare the different algorithms. They a Gaussian mixture learning. They can contrast kNN classifiers, neural networks, and support vec r basic application areas and algorithmic properties. Students can describe basic clustering technique mponents of those techniques. Students compare related machine learning techniques, e.g., k-mea eighbor classification. They can distinguish various ensemble learning techniques and compare t		
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination	00 minutes			
Examination Examination duration and	90 minutes			
	90 minutes			
Examination duration and scale Assignment for the	Computer Science: Specialisation II: Inte	ligence Engineering: Elective Compulsory		
Examination duration and scale	Computer Science: Specialisation II: Inte International Management and Engineer	ng: Specialisation II. Information Technology: Elec	tive Compulsory	
Examination duration and scale Assignment for the	Computer Science: Specialisation II: Inte International Management and Engineer Mechatronics: Technical Complementary	ng: Specialisation II. Information Technology: Elect Course: Elective Compulsory	tive Compulsory	
Examination duration and scale Assignment for the	Computer Science: Specialisation II: Inte International Management and Engineer Mechatronics: Technical Complementary Mechatronics: Specialisation System Des	ng: Specialisation II. Information Technology: Elect Course: Elective Compulsory	tive Compulsory	

Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	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, 2 18-21
	2. Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press 2012

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

Courses					
Title		Тур	Hrs/wk	СР	
Applied Design Methodology in Med	hatronics (L1523)	Lecture	2	2	
Applied Design Methodology in Mee	hatronics (L1524)	Project-/problem-based Learning	3	4	
Module Responsible	Prof. Thorsten Kern				
Admission Requirements	None				
Recommended Previous	Basics of mechanical design, electrical design o	r computer-sciences			
Knowledge					
Educational Objectives	After taking part successfully, students have re	ached the following learning results			
Professional Competence					
Knowledge	Science-based working on interdisciplinary product design considering targeted application of specific product design techniques				
Skille					
SKIIIS	creative handling of processes used for scientific preparation and formulation of complex product design problems / Application various product design techniques following theoretical aspects.				
	various product design techniques following the	oretical aspects.			
Personal Competence					
Social Competence	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with applicatio				
	common, creative methodologies.				
Autonomy	Students are enabled to optimize the design an	d development process according to the target a	nd topic of the	e design	
Workload in Hours	Independent Study Time 110, Study Time in Le	cture 70			
Credit points	6				
Course achievement	None				
Examination	Subject theoretical and practical work				
Examination duration and	30 min Presentation for a group design-work				
scale					
Assignment for the	International Management and Engineering: Sp	ecialisation II. Product Development and Producti	on: Elective C	ompulsory	
Following Curricula	International Management and Engineering: Sp	ecialisation II. Mechatronics: Elective Compulsory			
	Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory				
	Mechatronics: Specialisation System Design: Elective Compulsory				
		Organs and Regenerative Medicine: Elective Con	npulsory		
	Biomedical Engineering: Specialisation Implants				
		Technology and Control Theory: Elective Compute	-		
	biomedical Engineering: Specialisation Manage	ment and Business Administration: Elective Comp	ouisory		

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

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

Courses					
Fitle	action (1.2440)	Typ Lecture	Hrs/wk 2	CP 4	
light Control Law Design and Appli light Control Law Design and Appli		Project-/problem-based Learning	2	2	
Module Responsible					
-	None				
Recommended Previous	Basic Knowledge in:				
Knowledge	* Mathematics (Linear Algebra and ordinary differentia	al equations)			
	* Control Systems (Transfer functions and state space	representation)			
	* Mechanics (Rigid-body kinetics)				
	* Flight Mechanics				
Educational Objectives	After taking part successfully, students have reached	the following learning results			
Professional Competence					
Knowledge	Students are able to:				
	* describe and understand flight dynamics models for control tasks				
	* assess handling qualities and understand the need for augmentation through control systems				
	* identify fundamental limitations on performance of control laws				
Skills	Students are able to:				
	* design model-based control laws for stability augmentation				
	* design model-based flight control laws				
	* assess robustness and performance of control laws				
Personal Competence					
Social Competence	Students are able to:				
	* design control laws in groups as well as discuss the	requirements and results			
Autonomy	Students are able to:				
	* reflect on the contents of lectures and extend their knowledge through literature research				
	* solve control design tasks with software tools				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	60 min				
scale					
		in a Communication			
-	Aircraft Systems Engineering: Core Qualification: Elect Mechatronics: Specialisation System Design: Elective				

Course L2448: Flight Control	Law Design and Application				
Тур	Lecture				
Hrs/wk	2				
СР	4				
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28				
Lecturer	Prof. Frank Thielecke, Dr. Julian Theis				
Language	EN				
Cycle	SoSe				
Content	* flight dynamics (equations of motion, trim and linearization, linear models of longitudinal and lateral-directional motion, eigenforms)				
	* stability augmentation (modal dynamics, damper design with rool-loci, eigenstructure assignment)				
	* autopilots (control law design with loopshaping, robustness criteria and analysis, cascaded control loops, gain-scheduling)				
	* design of flight control laws				
	* verification of flight control laws in simulation				
	* implementation and application of flight control laws in embedded systems				
	* flight testing of flight control laws				
Literature	B. Stevens, F. Lewis: Aircraft Control and Simulation				
	D. Schmidt: Modern Flight Dynamics				
	D. McGruer, D. Graham, I. Ashkenas: Aircraft Dynamics and Automatic Control				
	G. Stein: Respect the Unstable, in: IEEE Control Systems Magazine SAE Aerospace Standard 94900 - Flight Control Systems				
	The MathWorks: Control Systems Design Toolbox User Guide				
	The MathWorks: Embedded Coder Support Package for PX4 Autopilots User Guide				

Course L2449: Flight Control Law Design and Application				
Тур	Project-/problem-based Learning			
Hrs/wk	2			
СР	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Frank Thielecke, Dr. Julian Theis			
Language	EN			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Module M0746: Micro	system Engineerir	g						
Courses								
Title			Тур	Hrs/wk	СР			
Microsystem Engineering (L0680)			Lecture	2	4			
Microsystem Engineering (L0682)	Project-/problem-based Learning 2 2							
	Dr. rer. nat. Thomas Kusserow							
Admission Requirements								
	Basic courses in physics, mathematics and electric engineering							
Knowledge								
	After taking part successfully, students have reached the following learning results							
Professional Competence	The students know about the most important technologies and materials of MEMS as well as their applications is searces as							
Knowledge	The students know about the most important technologies and materials of MEMS as well as their applications in sensors and actuators.							
Personal Competence	microsystems.							
Social Competence	Students are able to solve specific problems alone or in a group and to present the results accordingly.							
Autonomy	Students are able to acquire particular knowledge using specialized literature and to integrate and associate this knowledge wit other fields.							
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56							
Credit points	6							
Course achievement	Compulsory Bonus For							
		sentation						
Examination								
Examination duration and scale	2n							
	Electrical Engineering Cons Overlifection Computers							
-	Electrical Engineering: Core Qualification: Compulsory							
i ononing carricula	International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory							
	Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory							
	Mechatronics: Specialisation System Design: Elective Compulsory							
	Microelectronics and Microsystems: Core Qualification: Elective Compulsory							
	Theoretical Mechanical En	ineering: Specialisation Bio- and Medi	cal Technology: Elective Compu	lsory				

Course L0680: Microsystem	Engineering
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. rer. nat. Thomas Kusserow
Language	EN
Cycle	WiSe
Content	Object and goal of MEMS
	Scaling Rules
	Lithography
	Film deposition
	Structuring and etching
	Energy conversion and force generation
	Electromagnetic Actuators
	Reluctance motors
	Piezoelectric actuators, bi-metal-actuator
	Transducer principles
	Signal detection and signal processing
	Mechanical and physical sensors
	Acceleration sensor, pressure sensor
	Sensor arrays
	System integration
	Yield, test and reliability
Literature	M. Kasper: Mikrosystementwurf, Springer (2000)
	M. Madou: Fundamentals of Microfabrication, CRC Press (1997)

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

Courses					
Title		Тур	Hrs/wk	СР	
Technical Acoustics II (Room Acoustics, Computational Methods) (L0519)		Lecture	2	3	
	tics, Computational Methods) (L0521)	Recitation Section (large)	2	3	
-	Prof. Benedikt Kriegesmann				
Admission Requirements					
	Technical Acoustics I (Acoustic Waves, Noise Prote	ection, Psycho Acoustics)			
Knowledge	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 successfully, students have reach	hed the following learning results			
Professional Competence					
Knowledge	e The students possess an in-depth knowledge in acoustics regarding room acoustics and computational methods and are a give an overview of the corresponding theoretical and methodical basis.				
C1:11-	The shidests are eachly to be all environments and there is an other by the sector of any institution of the descention				
SKIIIS	//s The students are capable to handle engineering problems in acoustics by theory-based application of computational methods and procedures treated within the module.				
Personal Competence					
Social Competence	Students can work in small groups on specific prol	blems to arrive at joint solutions.			
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possib				
	conflicting issues and limitations can be identified and the results are critically scrutinized.				
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ıre 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	20-30 Minuten				
scale					
Assignment for the	Aircraft Systems Engineering: Core Qualification: I	Elective Compulsory			
Following Curricula	Mechatronics: Specialisation System Design: Elect	ive Compulsory			
	Product Development, Materials and Production: C	Core Qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation	n Product Development and Production: El-	ective Compulsory	(
	Theoretical Mechanical Engineering: Specialisation	a Simulation Technology: Elective Compute	sorv		

Typ Lecture Hrs/wk 2 Cols 3 Workload in Hours Independent Study Time 62, Study Time in Lecture 28 Lecture DrIng. Sören Keuchel Language EN Content - Room acoustics - Sound absorber - Standard computations - Statistical Energy Approaches - Finite Element Methods - Boundary Element Methods - Boundary Element Methods - Special formulations - Special formulations - Special formulations - Special formulations - Practical applications - Interchische Akustik. Vogel-Buchverlag, Berlin Veit, I. (1988): Töcknische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg Veit, Vieweg, Braunschweig, Wiesbaden		ustics II (Room Acoustics, Computational Methods)			
CP 3 Workload in Hours Independent Study Time 62, Study Time in Lecture 28 Lecturer DrIng. Sören Keuchel Language EN Cycle WiSe Content - Room acoustics - Sound absorber - Standard computations - 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 Vürzburg Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden	Тур	Lecture			
Workload in Hours Independent Study Time 62, Study Time in Lecture 28 Lecturer DrIng. Sören Keuchel Language EN Cycle WiSe Content - Room acoustics - Sound absorber - Standard computations - Statistical Energy Approaches - Finite Element Methods - Boundary Element Methods - Geometrical acoustics - Special formulations - Special formulations - Practical applications - Practical applications - Hands-on Sessions: Programming of elements (Matlab) - Vert, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. 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	Hrs/wk	2			
Lecturer DrIng. Sören Keuchel Language EN Cycle WiSe Content - Room acoustics - Sound absorber - Standard computations - Statistical Energy Approaches - Statistical Energy Approaches - Finite Element Methods - Boundary Element Methods - Geometrical acoustics - Special formulations - 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	СР	3			
Language EN Cycle WiSe Content - Room acoustics - Sound absorber - Standard computations - Statistical Energy Approaches - Statistical Energy Approaches - Finite Element Methods - Boundary Element Methods - Geometrical acoustics - Special formulations - Special formulations - Practical applications - Hands-on Sessions: Programming of elements (Matlab) - Practical applications - Hands-on Sessions: Programming of elements (Matlab) - Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, 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	Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
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): Technische Akustik. Vogel-Buchverlag, Würzburg Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden	Lecturer	DrIng. Sören Keuchel			
Content - Room acoustics - Sound absorber - Standard computations - Statistical Energy Approaches - Statistical Energy Approaches - Finite Element Methods - Boundary Element Methods - Boundary Element Methods - Geometrical acoustics - Special formulations - Special formulations - Practical applications - 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	Language	EN			
 Sound absorber 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 	Cycle	WiSe			
 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 Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden 	Content	- Room acoustics			
Statistical Energy Approaches Finite Element Methods Boundary Element Methods Geometrical acoustics Special formulations Practical applications 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		- Sound absorber			
Statistical Energy Approaches Finite Element Methods Boundary Element Methods Geometrical acoustics Special formulations Practical applications 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		Standard computations			
 Finite Element Methods Boundary Element Methods Geometrical acoustics 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					
Boundary Element Methods Geometrical acoustics Special formulations Practical applications 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					
Geometrical acoustics Special formulations Practical applications 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					
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					
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		- Special formulations			
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					
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					
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		- Hands-on Sessions: Programming of elements (Matlab)			
Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden	Literature	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin			
Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden		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		Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin			

Course L0521: Technical Aco	urse L0521: Technical Acoustics II (Room Acoustics, Computational Methods)		
Тур	Recitation Section (large)		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	DrIng. Sören Keuchel		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses					
Title		Тур	Hrs/wk	СР	
Nonlinear Structural Analysis (L027	7)	Lecture	3	4	
Nonlinear Structural Analysis (L027		Recitation Section (small)	1	2	
Module Responsible	Prof. Alexander Düster				
Admission Requirements	None				
Recommended Previous	Knowledge of partial differential equations is	recommended.			
Knowledge					
Educational Objectives	After taking part successfully, students have	reached the following learning results			
Professional Competence					
Knowledge	Students are able to				
	+ give an overview of the different nonlinea	phenomena in structural mechanics.			
	+ explain the mechanical background of nor	linear phenomena in structural mechanics.			
	+ to specify problems of nonlinear structura	I analysis, to identify them in a given situation a	and to explain the	eir mathematical a	
	mechanical background.				
Skille	Students are able to				
JKIIIS	+ model nonlinear structural problems.				
	+ select for a given nonlinear structural problems.	lem 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.				
	+ present and discuss their results in front of	f others.			
	+ give and accept professional constructive	criticism.			
Autonomi	Chudonka ava abla ka				
Autonomy	Students are able to + assess their knowledge by means of exerc	isos and E Loarning			
	+ acquaint themselves with the necessary k				
	+ to transform the acquired knowledge to si				
	i to transform the acquired knowledge to si	initial problems.			
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56			
Credit points					
Course achievement	None				
Examination	Written exam				
Examination duration and	120 min				
scale					
Assignment for the	Civil Engineering: Specialisation Structural E	ngineering: Elective Compulsory			
Following Curricula		Specialisation II. Civil Engineering: Elective Com	pulsory		
-	Materials Science: Specialisation Modeling: I		-		
	Mechatronics: Specialisation System Design				
	Product Development, Materials and Product				
	Naval Architecture and Ocean Engineering:				
	Ship and Offshore Technology: Core Qualific	ation: Elective Compulsory			
	Theoretical Mechanical Engineering: Special	sation Simulation Technology: Elective Compulse	arv		

Course L0277: Nonlinear Stru	uctural Analysis
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Düster
Language	DE/EN
Cycle	WiSe
Content	1. Introduction
	2. Nonlinear phenomena
	3. Mathematical preliminaries
	4. Basic equations of continuum mechanics
	5. Spatial discretization with finite elements
	6. Solution of nonlinear systems of equations
	7. Solution of elastoplastic problems
	8. Stability problems
	9. Contact problems
Literature	[1] Alexander Düster, Nonlinear Structrual Analysis, Lecture Notes, Technische Universität Hamburg-Harburg, 2014.
	[2] Peter Wriggers, Nonlinear Finite Element Methods, Springer 2008.
	[3] Peter Wriggers, Nichtlineare Finite-Elemente-Methoden, Springer 2001.
	[4] Javier Bonet and Richard D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press,
	2008.

Course L0279: Nonlinear Str	urse L0279: Nonlinear Structural Analysis		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	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				
Fitle		Turn	Hrs /w/r	CP
Advanced Topics in Control (L0661)		Typ Lecture	Hrs/wk 2	СР 3
Advanced Topics in Control (L0662)		Recitation Section (small)	2	3
Module Responsible				
-	None			
	H-infinity optimal control, mixed-sensitivity desigr	n, linear matrix inequalities		
Knowledge		·		
Educational Objectives	After taking part successfully, students have read	hed the following learning results		
Professional Competence				
Knowledge Skills	 Students can explain the advantages and s They can explain the representation of non They can explain how stability and perform They can explain how gridding techniques They are familiar with polytopic and LFT associated with each of these model struct Students can explain how graph theoreti systems They can explain the convergence properti They can explain analysis and synthesis co Students can construct LPV models of a controllers; they can do this using polytopic They can use standard software tools (Matley Students can design distributed formation) 	linear systems in the form of quasi-LPV systems can be form can be used to solve analysis and synthesis representations of LPV systems and som ures ic concepts are used to represent the co es of first order consensus protocols nditions for formation control loops involvin- ar and qLPV Model Predictive Control (MPC) nonlinear plants and carry out a mixed- c, LFT or general LPV models ab robust control toolbox) for these tasks	sensitivity desig	' systems synthesis techniqu bology of multiage V agent models n of gain-schedule
Personal Competence	tools provided Students can design MPC controllers for linear and non-linear systems using Matlab tools 			
-	Students can work in small groups and arrive at jo	pint results.		
	Students can find required information in sources given problems.		re documentatior	n) and use it to sol
	Independent Study Time 124, Study Time in Lectu	ure 56		
Credit points				
Course achievement				
Examination				
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Control and	Power Systems Engineering: Elective Comp	ulsory	
	Aircraft Systems Engineering: Core Qualification:	Elective Compulsory		
-	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory			
-	International Management and Engineering: Spec			
-	International Management and Engineering: Spec Mechatronics: Specialisation System Design: Elect	tive Compulsory		
-				
-	Mechatronics: Specialisation System Design: Elect Mechatronics: Specialisation Intelligent Systems a Biomedical Engineering: Specialisation Implants a	nd Robotics: Elective Compulsory nd Endoprostheses: Elective Compulsory		
-	Mechatronics: Specialisation System Design: Elect Mechatronics: Specialisation Intelligent Systems a Biomedical Engineering: Specialisation Implants a Biomedical Engineering: Specialisation Medical Te	nd Robotics: Elective Compulsory nd Endoprostheses: Elective Compulsory echnology and Control Theory: Elective Com		
-	Mechatronics: Specialisation System Design: Elect Mechatronics: Specialisation Intelligent Systems a Biomedical Engineering: Specialisation Implants a	and Robotics: Elective Compulsory nd Endoprostheses: Elective Compulsory echnology and Control Theory: Elective Com ent and Business Administration: Elective Co	ompulsory	

Тур	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Herbert Werner			
Language	EN			
Cycle	WiSe			
Content	Linear Parameter-Varying (LPV) Gain Scheduling			
	- Linearizing gain scheduling, hidden coupling			
	- Jacobian linearization vs. quasi-LPV models			
	- Stability and induced L2 norm of LPV systems			
	- Synthesis of LPV controllers based on the two-sided projection lemma			
	- Simplifications: controller synthesis for polytopic and LFT models			
	- Experimental identification of LPV models			
	- Controller synthesis based on input/output models			
	- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator			
	Control of Multi-Agent Systems			
	- Communication graphs			
	- Spectral properties of the graph Laplacian			
	- First and second order consensus protocols			
	- Formation control, stability and performance			
	- LPV models for agents subject to nonholonomic constraints			
	- Application: formation control for a team of quadrotor helicopters			
	Linear and Nonlinear Model Predictive Control based on LMIs			
Literature	Werner, H., Lecture Notes "Advanced Topics in Control"			
	 Selection of relevant research papers made available as pdf documents via StudIP 			

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

Courses					
Title		Тур	Hrs/wk	СР	
Integrated Product Development II		Lecture	3	3	
Integrated Product Development II		Project-/problem-based Learning	2	3	
Module Responsible					
Admission Requirements	None				
Recommended Previous	Basic knowledge of Integrated product development	and applying CAE systems			
Knowledge	After teling part successfully, students have reache	d the fellowing learning results			
Professional Competence	After taking part successfully, students have reached	a the following learning results			
-	After passing the module students are able to:				
Kilowicuge					
	explain technical terms of design methodolog				
	describe essential elements of construction m	-			
	describe current problems and the current sta	ate of research of integrated product develop	iment.		
Skills	After passing the module students are able to:				
	 select and apply proper construction methods for non-standardized solutions of problems as well as adapt new boundar 				
	 select and apply proper construction methods for hon-standardized solutions of problems as well as adapt conditions, solve product development problems with the assistance of a workshop based approach, 				
	 choose and execute appropriate moderation t 				
Devecuel Commetence					
Personal Competence	After passing the module students are able to:				
Social competence	Arter passing the module students are able to.				
	 prepare and lead team meetings and modera 	tion processes,			
	 work in teams on complex tasks, 				
	 represent problems and solutions and advance 	e ideas.			
Autonomy	After passing the module students are able to:				
	 give a structured feedback and accept a critic 	al foodback			
	 give a structured feedback and accept a critical feedback, implement the accepted feedback autonomous. 				
Workload in Hours	Independent Study Time 110, Study Time in Lecture	70			
Credit points	6				
Course achievement	None				
Examination					
Examination duration and	30 Minuten				
scale					
-	Aircraft Systems Engineering: Core Qualification: Ele				
Following Curricula	International Management and Engineering: Special		on: Elective C	ompulsory	
	Mechatronics: Specialisation System Design: Elective				
	Product Development, Materials and Production: Spe		У		
	Product Development, Materials and Production: Spe				
	Product Development, Materials and Production: Spe		- Commula		
	Theoretical Mechanical Engineering: Specialisation P	roduct Development and Production: Elective	e compuisory		

Course L1254: Integrated Pro	oduct Development II
Тур	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Dieter Krause
Language	
Cycle	
Content	
	The lecture extends and enhances the learned content of the module "Integrated Product Development and lightweight design and is based on the knowledge and skills acquired there.
	Topics of the course include in particular:
	Methods of product development,
	Presentation techniques,
	Industrial Design,
	Design for variety
	Modularization methods,
	Design catalogs,
	Adapted QFD matrix,
	Systematic material selection,
	Assembly oriented design,
	Construction management
	CE mark, declaration of conformity including risk assessment,
	Patents, patent rights, patent monitoring
	 Project management (cost, time, quality) and escalation principles,
	 Development management for mechatronics,
	Technical Supply Chain Management.
	Exercise (PBL)
	In the exercise the content presented in the lecture "Integrated Product Development II" and methods of product development an design management will be enhanced.
	Students learn an independently moderated and workshop based approach through industry related practice examples to sol- complex and currently existing issues in product development. They will learn the ability to apply important methods of produ development and design management autonomous and acquire further expertise in the field of integrated product developmer Besides personal skills, such as teamwork, guiding discussions and representing work results will be acquired through the workshop based structure of the event under its own planning and management.
Literature	 Andreasen, M.M., Design for Assembly, Berlin, Springer 1985. Ashby, M. F.: Materials Selection in Mechanical Design, München, Spektrum 2007. Beckmann, H.: Supply Chain Management, Berlin, Springer 2004. Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater ur Trainer, Weinheim, Beltz 2007. Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006. Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000. Simpson, T.W., Siddique, Z., Jiao, R.J.: Product Platform and Product Family Design. Methods and Applications, New Yorl Springer 2013.

Course L1255: Integrated Pro	urse 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		

Module M1173: Appli	ed Statistics			
Courses				
Title	Тур		Hrs/wk	СР
Applied Statistics (L1584)	Lectu	re	2	3
Applied Statistics (L1586)	Projec	ct-/problem-based Learning	2	2
Applied Statistics (L1585)	Recitation Section (small) 1 1			
Module Responsible				
Admission Requirements	None			
	Basic knowledge of statistical methods			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following lea	rning results		
Professional Competence				
-	Students can explain the statistical methods and the conditions of their			
	Students are able to use the statistics program to solve statistics probl	ems and to interpret and d	epict the resu	Its
Personal Competence	Toops Work, ising proceptation of regults			
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 Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes, 28 questions			
scale				
Assignment for the	Mechanical Engineering and Management: Specialisation Management	: Elective Compulsory		
Following Curricula	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: Ele			
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Te	cnnology: Elective Compute	sory	
Course L1584: Applied Statis	tics			
Тур	Lecture			
Hrs/wk				
CP	3			
	Independent Study Time 62, Study Time in Lecture 28			
	Prof. Michael Morlock			
Language				
Cycle				
	The goal is to introduce students to the basic statistical methods and t	heir application to simple p	roblems. The	topics include:
	Simple regression and correlation			
	Multiple regression and correlation			
	One way analysis of variance			
	Two way analysis of variance			
	Discriminant analysis			
	Analysis of categorial data			

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

Chossing the appropriate statistical method

.

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

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

Courses				
Title		Тур	Hrs/wk	СР
Flexible Multibody Systems (L1632		Lecture	2	3
Optimization of dynamical systems		Lecture	2	3
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous Knowledge	Mathematics I, II, III			
Kilowiedge	Mechanics I, II, III, IV			
	 Simulation of dynamical Systems 			
Educational Objectives	After taking part successfully, students have	ve reached the following learning results		
Professional Competence				
Knowledge	Students demonstrate basic knowledge a	nd understanding of modeling, simulation	n and analysis of compl	ex rigid and flexib
	multibody systems and methods for optimi	zing dynamic systems after successful con	npletion of the module.	
Skills	Students are able			
	+ to think holistically			
	+ to independently, securly and critically	analyze and optimize basic problems of	the dynamics of rigid a	nd flexible multibo
	systems	· · · · · · · · · · · · · · · · · · ·		
	+ to describe dynamics problems mathema	atically		
	+ to optimize dynamics problems			
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous groups	and to document the corresponding result	ts.	
	i solve problems in neterogeneous groups	and to document the corresponding result		
Autonomy	Students are able to			
Autonomy				
	+ assess their knowledge by means of exer	rcises.		
	+ acquaint themselves with the necessary	knowledge to solve research oriented task	S.	
Workload in Hours	Independent Study Time 124, Study Time i	n Lecture 56		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
5	Energy Systems: Core Qualification: Electiv	1 2		
Following Curricula	Aircraft Systems Engineering: Core Qualific			
	Mechatronics: Specialisation System Design			
	Mechatronics: Specialisation Intelligent Sys			
	Product Development, Materials and Product		ory	
	Theoretical Mechanical Engineering: Core C	Dualification: Elective Compulsory		

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

Course L1633: Optimization	of dynamical systems
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried, Dr. Svenja Drücker
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.

Lecturer Prof. Norbert Hoffmann DE/EN

> • Linear Waves Dispersion

> > Envelopes • Discrete Systems

Model Equations

• Water Waves, Ocean Waves Airy and Stokes • Natural Sea State • Kinetic Modelling

Literature F.K. Kneubühl: Oscillations and Waves. Springer.

G.B. Witham, Linear and Nonlinear Waves. Wiley.

C.C. Mei, Theory and Applications of Ocean Surface Waves. World Scientific.

L.H. Holthuijsen, Waves in Oceanic and Coastal Waters. Cambridge.

Nonlinear Waves

• Other topics

And others.

Content Introduction into the Dynamics of Linear and Nonlinear Waves

• Phase and Group Velocity

• Solitons, Breathers, Extreme Waves

WiSe Cycle

Language

Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear Waves (L173	7)	Project-/problem-based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus, Algebra, Engineering Mechanics, Vibrations.			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	 Students are able to reflect existing terms and concept 	in Wave Mechanics		
	 Students are able to renect existing terms and concept Students are able to identify and express the need to d 		nts	
	· Students are use to rachtry and express the need to a			
Skills	 Students are able to apply existing research methods a 	nd procedures of wave mechanics		
	 Students are able to develop novel research methods a 			
Personal Competence				
Social Competence	 Students can reach working results also in groups. 			
	 Students can present and communicate working re 	sults also in groups.		
	, , , , , , , , , , , , , , , , , , , ,	5 .		
Autonomy	 Students are able to approach given research tasks ind 	ividually.		
	 Studetns are able to identify and follow up novel resear 			
Workload in Hours				
Credit points				
Course achievement				
Examination				
Examination duration and	2 Hours			
scale	Machatranica: Crasialization Custom Design: Flastive Can	an de an c		
-	Mechatronics: Specialisation System Design: Elective Con			
Pollowing curricula	Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Marin Theoretical Mechanical Engineering: Specialisation Simula			
	medicina Mechanical Engineering. Specialisation Sinda	alon recinology. Elective compulsory		
Course L1737: Linear and No	nlinear Waves			
	Project-/problem-based Learning			
Hrs/wk	4			
CP	6			
Workload in Hours				

Module M1229: Contr	ol Lab B			
Courses				
Title		Тур	Hrs/wk	СР
Control Lab V (L1667)		Practical Course	1	1
Control Lab VI (L1668)		Practical Course	1	1
Module Responsible				
Admission Requirements	None			
Recommended Previous	State space methods			
Knowledge	LQG control			
	 H2 and H-infinity optimal control 			
	uncertain plant models and robus	t control		
	LPV control			
Educational Objectives	After taking part successfully, students h	nave reached the following learning results		
Professional Competence				
Knowledge				
	 Students can explain the difference 	ce between validation of a control lop in simulati	on and experimental	validation
Skills				
		g basic system identification tools (Matlab Sys	stem Identification To	polbox) to identif
	dynamic model that can be used	-		
		lard software tools (Matlab Control Toolbox) fo	r the design and imp	plementation of L
	controllers			
		rd software tools (Matlab Robust Control Toolbo>	<) for the mixed-sensi	tivity design and
	implementation of H-infinity optin			
		model uncertainty, and of designing and implem	-	
		rd software tools (Matlab Robust Control Toolbox) for the design and th	ne implementation
	LPV gain-scheduled controllers			
Personal Competence				
Social Competence				
	 Students can work in teams to con 	nduct experiments and document the results		
Autonomy				
Autonomy	Students can independently carry	out simulation studies to design and validate co	ontrol loops	
Workload in Hours	Independent Study Time 32, Study Time	in Lecture 28		
Credit points				
Course achievement				
Examination	Written elaboration			
Examination duration and				
scale	<u></u>			
	Electrical Engineering: Specialization Co	ntrol and Power Systems Engineering: Elective C	ompulson	
Following Curricula		Systems and Robotics: Elective Compulsory	ompuisory	
Following Curricula				
	Mechatronics: Specialisation System Des	sign: Elective Compulsory		

Course L1667: Control Lab V	
Тур	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Herbert Werner, Adwait Datar, Patrick Göttsch
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

Course L1668: Control Lab V	urse L1668: Control Lab VI		
Тур	Practical Course		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Herbert Werner, Adwait Datar, Patrick Göttsch		
Language	EN		
Cycle	WiSe/SoSe		
Content	One of the offered experiments in control theory.		
Literature	Experiment Guides		

Module M1305: Semii	nar Advanced Topics in Con	trol		
Courses				
Title Advanced Topics in Control (L1803))	Typ Seminar	Hrs/wk	CP 2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	 Introduction to control systems Control theory and design optimal and robust control 			
Educational Objectives	After taking part successfully, students	have reached the following learning results		
Professional Competence				
Knowledge	Students can explain modern conStudents learn to apply basic con			
Skills		It selected aspects of modern control, based o sults and present them to the participants give a presentation	n specified literature	
Personal Competence				
Social Competence	 Students are capable of developing 	ng solutions and present them ate feedback and handle constructive criticisn	n of their own results	
Autonomy	solution	and drawbacks of different forms of present with a scientific field, are able of introduce it levelops	·	
Workload in Hours	Independent Study Time 32, Study Time	e in Lecture 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and scale	90 min			
Assignment for the	Mechatronics: Specialisation System De	sign: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent	Systems and Robotics: Elective Compulsory		

Course L1803: Advanced Top	Course L1803: Advanced Topics in Control		
Тур	Seminar		
Hrs/wk	2		
CP	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Herbert Werner		
Language			
Cycle	ie/SoSe		
Content	Seminar on selected topics in modern control		
Literature	To be specified		

Courses					
	and Control of Autonomous Vehicles (L2869) n into Mobile Underwater Robotics (L1981)	Typ Integrated Lecture Project-/problem-based Learning	Hrs/wk 1 4	CP 1 5	
Module Responsible	Prof. Robert Seifried				
Admission Requirements	None				
Recommended Previous Knowledge	Mechanics IV, Applied Dynamics or Robotics Numerical Treatment of Ordinary Differential Equation	ons			
	Control Systems Theory and Design				
Educational Objectives	After taking part successfully, students have reached	d the following learning results			
Professional Competence					
Knowledge	After successful completion of the module students demonstrate deeper knowledge and understanding in selected applicati areas of multibody dynamics and robotics				
Skills	5 Students are able				
	+ to think holistically				
	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibod systems				
	+ to describe dynamics problems mathematically				
	+ to implement dynamical problems on hardware				
Personal Competence					
Social Competence	Students are able to				
	+ solve problems in heterogeneous groups and to do	ocument the corresponding results and prese	ent them		
Autonomy	/ Students are able to				
	+ assess their knowledge by means of exercises and projects.				
	+ acquaint themselves with the necessary knowledg	e to solve research oriented tasks.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture	70			
Credit points	6				
Course achievement	None				
Examination	Presentation				
	ТВА				
scale	Machatanian Consisting Intelligent Const	Debeties Elective Communer			
-	Mechatronics: Specialisation Intelligent Systems and				
Following Curricula	Mechatronics: Specialisation System Design: Elective	e compulsorv			

Course L2869: Formulas and	ourse L2869: Formulas and Vehicles - Dynamics and Control of Autonomous Vehicles		
Тур	Integrated Lecture		
Hrs/wk	1		
CP	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Robert Seifried, Daniel-André Dücker		
Language	DE		
Cycle	WiSe		
Content			
Literature			

Course L1981: Formulas and	Vehicles - Introduction into Mobile Underwater Robotics
Тур	Project-/problem-based Learning
Hrs/wk	4
CP	5
Workload in Hours	Independent Study Time 94, Study Time in Lecture 56
Lecturer	Prof. Robert Seifried, Daniel-André Dücker
Language	DE
Cycle	WiSe
Content	
Literature	Seifried, R.: Dynamics of underactuated multibody systems, Springer, 2014
	Popp, K.; Schiehlen, W.: Ground vehicle dynamics, Springer, 2010

Courses					
Title		Тур	Hrs/wk	СР	
Mathematical Image Processing (L0991)		Lecture	3	4	
Mathematical Image Processing (LC		Recitation Section (small)	1	2	
Module Responsible	Prof. Marko Lindner				
Admission Requirements	None				
Recommended Previous					
Knowledge	Analysis: partial derivatives, gradi	ent, directional derivative			
Riomeuge	Linear Algebra: eigenvalues, least	squares solution of a linear system			
Educational Objectives	After taking part successfully, students h	nave reached the following learning results			
Professional Competence	After taking part successiony, students i	lave reached the following learning results			
	Students are able to				
Knowledge					
	characterize and compare diffusion	on equations			
	 explain elementary methods of im 	nage processing			
	 explain methods of image segment 	ntation and registration			
	sketch and interrelate basic conce	epts of functional analysis			
Skills	Students are able to				
Skiis					
 implement and apply elementary methods of image processing 					
	explain and apply modern method	ls of image processing			
Personal Competence					
-	Students are able to work together	in heterogeneously composed teams (i.e., tea	ns from different	study programs a	
Social competence	background knowledge) and to explain t		no nom uncrenc	study programs a	
Autonomy	 Students are canable of checking 	their understanding of complex concents on the	ir own They can s	pecify open questio	
	 Students are capable of checking their understanding of complex concepts on their own. They can specify open question precisely and know where to get help in solving them. 				
		ent persistence to be able to work for longer pe	riods in a goal-orie	nted manner on ha	
	problems.	the persistence to be able to work for longer pe	nous in a goar one		
	P				
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	20 min				
scale					
Assignment for the	Bioprocess Engineering: Specialisation A	- General Bioprocess Engineering: Elective Comp	ulsory		
Following Curricula	Computer Science: Specialisation III. Mat	hematics: Elective Compulsory			
	Computer Science in Engineering: Specia	alisation III. Mathematics: Elective Compulsory			
	Interdisciplinary Mathematics: Specialisa	tion Computational Methods in Biomedical Imagir	ng: Compulsory		
	Mechatronics: Technical Complementary	Course: Elective Compulsory			
	Mechatronics: Specialisation System Des	sign: Elective Compulsory			
	Mechatronics: Specialisation Intelligent S	systems and Robotics: Elective Compulsory			
	Technomathematics: Specialisation I. Ma	thematics: Elective Compulsory			
	Theoretical Mechanical Engineering: Spe	cialisation Robotics and Computer Science: Electi	ve Compulsory		
	Process Engineering: Specialisation Proc				

Course L0991: Mathematical	Image Processing	
Тур	Lecture	
Hrs/wk		
CP		
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	urse L0992: Mathematical Image Processing		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	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		

Courses				
itle		Тур	Hrs/wk	СР
ntegrated Circuit Design (L0691)		Lecture	3	4
ntegrated Circuit Design (L0998)		Recitation Section (small)	1	2
Module Responsible Prof. Matth	ias Kuhl			
Admission Requirements None				
Recommended Previous Basic know	ledge of (solid-state) physics and mathem	atics.		
Knowledge Knowledge	in fundamentals of electrical engineering	and electrical networks.		
Educational Objectives After takin	part successfully, students have reached	the following learning results		
Professional Competence				
gen • Stud • Stud • Stud • Stud • Stud • Stud • Stud	ents can explain basic concepts ration/recombination, carrier concentratic ents are able to explain functional principl ents can present and discuss current-volta ents can explain the physics and current-v ents are able to explain the basic concept ents can exemplify approaches for low po ents can describe the potential and limitat ents can explain characterization techniqu	ons, drift and diffusion current densities es of pn-diodes, MOS capacitors, and M age relationships and small-signal equiv voltage behavior transistors based on c s for static and dynamic logic gates for wer consumption on the device and cirr tions of analytical expression for device	, semiconductor dev MOSFETs using energy valent circuits of the harged carrier flow. integrated circuits cuit level	vice equations). gy band diagrams ese devices.
Stud diag Stud Stud Stud Stud Stud Stud Stud	 Students can qualitatively construct energy band diagrams of the devices for varying applied voltages. Students are able to qualitatively determine electric field, carrier concentrations, and charge flow from energy bad diagrams. Students can understand scientific publications from the field of semiconductor devices. Students can calculate the dimensions of MOS devices in dependence of the circuits properties Students can design complex electronic circuits and anticipate possible problems. Students know procedure for optimization regarding high performance and low power consumption 			
• Stud	ents can team up with other experts in the ents are able to work by their own or in sr ents have the ability to critically question	nall groups for solving problems and an	nswer scientific ques	stions.
	ents are able to assess their knowledge in ents are able to define their personal appr			
Workload in Hours Independe	nt Study Time 124, Study Time in Lecture	56		
Credit points 6				
Course achievement None				
Examination Written ex	am			
Examination duration and 90 min				
scale				
-	ngineering: Specialisation Nanoelectronics			
	al Management and Engineering: Specialis			
	Engineering and Management: Specialisa		1	
Mechatron	cs: Specialisation System Design: Elective	Compulsory		

Course L0691: Integrated Cir	cuit Design
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Electron transport in semiconductors Electronic operating principles of diodes, MOS capacitors, and MOS field-effect transistors MOS transistor as four terminal device Performace degradation due to short channel effects Scaling-down of MOS technology Digital logic circuits Basic analog circuits Operational amplifiers Bipolar and BiCMOS circuits
Literature	 Yuan Taur, Tak H. Ning: Fundamentals of Modern VLSI Devices, Cambridge University Press 1998 R. Jacob Baker: CMOS, Circuit Design, Layout and Simulation, IEEE Press, Wiley Interscience, 3rd Edition, 2010 Neil H.E. Weste and David Money Harris, Integrated Circuit Design, Pearson, 4th International Edition, 2013 John E. Ayers, Digital Integrated Circuits: Analysis and Design, CRC Press, 2009 Richard C. Jaeger and Travis N. Blalock: Microelectronic Circuit Design, Mc Graw-Hill, 4rd. Edition, 2010

Course L0998: Integrated Cir	rse L0998: Integrated Circuit Design		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Matthias Kuhl		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title		Тур	Hrs/wk	СР
Image Processing (L2443)		Lecture	2	4
Image Processing (L2444)		Recitation Section (small)	2	2
Module Responsible	Prof. Tobias Knopp			
Admission Requirements	None			
Recommended Previous	Signal and Systems			
Knowledge				
Educational Objectives	After taking part successfully, students have reach	hed the following learning results		
Professional Competence				
Knowledge	The students know about			
	 visual perception 			
	 multidimensional signal processing 			
	 sampling and sampling theorem 			
	 filtering 			
	image enhancement			
	edge detection			
	 multi-resolution procedures: Gauss and Lap 	place pyramid, wavelets		
	image compression			
	image segmentation			
	 morphological image processing 			
Skills	The students can			
	 analyze, process, and improve multidimens 	sional image data		
	implement simple compression algorithms			
	 design custom filters for specific application 	ns		
Personal Competence				
-	Students can work on complex problems both independently and in teams. They can exchange ideas with each other and use			
···· ,·· .	individual strengths to solve the problem.			
Autonomy	Students are able to independently investigate a o	complex problem and assess which compet	encies are require	ed to solve it.
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ıre 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Data Science: Core Qualification: Elective Compute	sory		
Following Curricula	Data Science: Specialisation I. Mathematics/Comp	uter Science: Elective Compulsory		
	Electrical Engineering: Specialisation Information	and Communication Systems: Elective Com	pulsory	
	Electrical Engineering: Specialisation Medical Tech	nnology: Elective Compulsory		
	Information and Communication Systems: Spe	cialisation Secure and Dependable IT S	ystems, Focus S	oftware and Sig
	Processing: Elective Compulsory			
	Information and Communication Systems: Special	isation Communication Systems, Focus Sigr	nal Processing: Ele	ective Compulsory
	International Management and Engineering: Speci	ialisation II. Information Technology: Electiv	e Compulsory	
	Mechatronics: Specialisation Intelligent Systems a	nd Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elect			
	Microelectronics and Microsystems: Specialisation			
	Theoretical Mechanical Engineering: Specialisation	n Robotics and Computer Science: Elective	Compulsory	

Course L2443: Image Proces	sing
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Tobias Knopp
Language	DE/EN
Cycle	WiSe
Content	 Visual perception Multidimensional signal processing Sampling and sampling theorem Filtering Image enhancement Edge detection Multi-resolution procedures: Gauss and Laplace pyramid, wavelets Image Compression Segmentation Morphological image processing
Literature	Bredies/Lorenz, Mathematische Bildverarbeitung, Vieweg, 2011 Pratt, Digital Image Processing, Wiley, 2001 Bernd Jähne: Digitale Bildverarbeitung - Springer, Berlin 2005

Course L2444: Image Processing		
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Tobias Knopp	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1596: Engin	eering Haptic S	ystems				
Courses						
Title			т	ур	Hrs/wk	СР
Haptic Technology for Human-Machine-Interfaces (HMI) (L2439)		L	ecture	4	3	
Haptic Technology for Human-Mach	hine-Interfaces (HMI) (L28	59)	Р	roject-/problem-based Learning	2	3
Module Responsible	Prof. Thorsten Kern					
Admission Requirements	None					
Recommended Previous	We recommend know	edge in the areas o	f general engineering so	ciences, mechatronics and/or	control-engine	eering. However a
Knowledge	neighbouring technica	l areas like mechani	ical-engineering or even	process-engineers can join the	e course and v	will be introduced i
-	the content properly.					
Educational Objectives		essfully, students ha	ve reached the following	learning results		
Professional Competence	51					
Knowledge	scratch. It covers a pl with consideration on	nysiological part, an control theory for	actuator development projects.	n-requirements to consider w part, and goes up to fundame Beside design-related topics ny examples. This is support	entals of highe s, it gives a v	er system integrat valuable overview
	 Motivation and 	application of haptic	systems			
	Hourdadin and applied of or happle systems Haptic perception					
		user in direct system	n interaction			
	Development of haptic systems					
	Identification of requirements					
	System-structure and control					
	Kinematic fundamentals					
	Actuation & Sensors technology for haptic applications					
	Control and system-design aspects					
		onsiderations in simu	ulating haptics			
Skills	towards the design a	nd application of a		y the general engineering ca he resulting competencies w levice-development.		
Personal Competence						
Social Competence	application of "haptics	s". It teaches metho		for human-machine-interfac lies, judge on user-feedback ception.		
Autonomy	Independent design-ca	apability of haptic sy	stems, general compete	ncy in engineering from a des	ign-perspectiv	ve
Workload in Hours	Independent Study Tir	ne 96, Study Time ir	n Lecture 84			
Credit points	6					
Course achievement	CompulsoryBonusYes20 %	Form Subject theoretic practical work	Description cal andDurchführung v	von Laborversuchen		
Examination	Subject theoretical and	d practical work				
Examination duration and	30 min					
scale						
Assignment for the	Mechatronics: Technic	al Complementary C	Course: Elective Compuls	ory		
÷	Mechatronics: Speciali	sation Intelligent Sy	stems and Robotics: Elec	ctive Compulsory		
-			n: Elective Compulsory			
				pment and Production: Electiv	e Compulsory	,

Тур	Lecture
Hrs/wk	4
CP	3
Workload in Hours	Independent Study Time 34, Study Time in Lecture 56
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	WiSe
Content	This course is an introduction to the design methods and design-requirements to consider when creating haptic systems from
	scratch. It covers a physiological part, an actuator development part, and goes up to fundamentals of higher system integratio
	with consideration on control theory for more complex projects. Beside design-related topics, it gives a valuable overview o
	existing haptic applications and research in that field with many examples.
	Motivation and application of haptic systems
	Haptic perception
	The role of the user in direct system interaction
	Development of haptic systems
	Identification of requirements
	System-structure and control
	Kinematic fundamentals
	Actuation & Sensors technology for haptic applications
	Control and system-design aspects
	Fundamental considerations in simulating haptics
Literature	

course 12059. Haptic Techno	biogy for numan-machine-interfaces (nm)
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Courses						
itle			Тур		Hrs/wk	СР
Optics for Engineers (L2437)			Lecture		3	3
Optics for Engineers (L2438)			Project-	/problem-based Learning	3	3
Module Responsible	Prof. Thorsten Kern					
Admission Requirements	None					
Recommended Previous	- Basics of physics					
Knowledge						
Educational Objectives	After taking part succ	cessfully, students have r	eached the following learn	ing results		
Professional Competence						
Knowledge	Teaching subject ist t	the design of simple optic	al systems for illumination	and imaging optics		
	De sie verlage fr					
		or optical systems and lig				
		ck-bodies, color-perceptic				
	-	und their characterization	1			
	 Photometrics 					
	 Ray-Optics 					
	 Matrix-Optics 					
	 Stops, Pupils a 	nd Windows				
	 Light-field Tec 	hnology				
	 Introduction to 	Wave-Optics				
	 Introduction to 	Holography				
Skills	Understandings of op	otics as part of light and e	lectromagnetic spectrum.	Design rules, approach t	o designing o	ptics
Personal Competence						
Social Competence						
Autonomy						
Workload in Hours	Independent Study T	ime 96, Study Time in Le	cture 84			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
Course achievement	Yes None	Subject theoretical	andTeilnahme an Laborü	bungen und Simulation		
	i co	practical work		bungen und Simulation		
Examination	Oral exam	practical work				
Examination duration and	30 min					
scale						
-			ve Engineering, Optics, and	d Electromagnetic Compa	atıbility: Electi	ve Compulsory
Following Curricula		ical Complementary Cour				
	Mechatronics: Specia	lisation Intelligent Syster	ns and Robotics: Elective C	Compulsory		
	Mechatronics: Specia	lisation System Design: E	Elective Compulsory			

Course L2437: Optics for Eng	jineers		
Тур	Lecture		
Hrs/wk			
CP			
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42		
Lecturer	Prof. Thorsten Kern		
Language	EN		
Cycle	WiSe		
Content	 Basic values for optical systems and lighting technology Spectrum, black-bodies, color-perception Light-Sources und their characterization Photometrics Ray-Optics Matrix-Optics Stops, Pupils and Windows Light-field Technology Introduction to Wave-Optics Introduction to Holography 		
Literature			

ourse L2438: Optics for Engineers		
Тур	Project-/problem-based Learning	
Hrs/wk	3	
CP	3	
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Prof. Thorsten Kern	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

	Thesis
Module M-002: Maste	r Thesis
Courses	
Title	Typ Hrs/wk CP
Module Responsible	Professoren der TUHH
Admission Requirements	According to General Regulations §21 (1):
	At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous	
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge Skills	 The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues. The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject describing current developments and taking up a critical position on them. The students can place a research task in their subject area in its context and describe and critically assess the state research. The students are able: To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or complex and/or course of their studies to complex and/
	incompletely defined problems in a solution-oriented way.To develop new scientific findings in their subject area and subject them to a critical assessment.
Personal Competence	
Social Competence	Students can
	 Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structure
	way.
	 Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressed while upholding their own assessments and viewpoints convincingly.
Autonomv	Students are able:
	 To structure a project of their own in work packages and to work them off accordingly. To work their way in depth into a largely unknown subject and to access the information required for them to do so. To apply the techniques of scientific work comprehensively in research of their own.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	30
	None
Course achievement	
Examination	
Examination Examination duration and	
Examination Examination duration and scale	According to General Regulations
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory
Examination Examination duration and scale	According to General Regulations Civil Engineering: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: 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
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: 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
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: 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 Mechanical Engineering and Management: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: 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 Mechanical Engineering and Management: Thesis: Compulsory Mechatronics: Thesis: Compulsory Mechatronics: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: 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 Mechanical Engineering and Management: Thesis: Compulsory
Examination Examination duration and scale Assignment for the	According to General Regulations Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Logistics, Infrastructure and Mobility: Thesis: Compulsory Materials Science: Thesis: Compulsory Mechanical Engineering and Management: Thesis: Compulsory Biomedical Engineering: Thesis: Compulsory

Naval Architecture and Ocean Engineering: Thesis: Compulsory
Ship and Offshore Technology: Thesis: Compulsory
Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory
Theoretical Mechanical Engineering: Thesis: Compulsory
Process Engineering: Thesis: Compulsory
Water and Environmental Engineering: Thesis: Compulsory
Certification in Engineering & Advisory in Aviation: Thesis: Compulsory