Module Manual

Master of Science (M.Sc.)

Mechatronics

Cohort: Winter Term 2021

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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 design
- Intelligent 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: Busin	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 Skills	 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. 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 Autonomy	 Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems 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 M0524: Non-t	Iodule M0524: Non-technical Courses for Master	
Module Responsible	Dagmar Richter	
Admission Requirements	None	
Recommended Previous	None	
Knowledge	Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Duefe selevel Commetence		

Professional Competence

Knowledae

The Nontechnical Academic Programms (NTA)

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

The Learning Architecture

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

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

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

Teaching and Learning Arrangements

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

Fields of Teaching

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

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

The Competence Level

of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc.

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

Specialized Competence (Knowledge)

Students can

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

Skills Professional Competence (Skills)

In selected sub-areas students can

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

Personal Competence

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 • 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 $\bullet \ \ \text{to reflect on their own profession and professionalism in the context of real-life fields of application}$ • 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)

Credit points 6

Workload in Hours Depends on choice of courses

Courses

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

Module M0563: Robot	tics			
Courses				
Title		Тур	Hrs/wk	СР
Robotics: Modelling and Control (LO		Integrated Lecture	4	4
Robotics: Modelling and Control (L1	.305)	Project-/problem-based Learning	2	2
Module Responsible	Dr. Martin Gomse			
Admission Requirements	None			
	Fundamentals of electrical engineering			
Knowledge	Broad knowledge of mechanics			
	Stodd Miomedge of Meenames			
	Fundamentals of control theory			
Educational Objectives	After taking part successfully, students have reached the follo	wing learning results		
Professional Competence				
Knowledge	Students are able to describe fundamental properties of robo	s and solution approaches for mult	iple problems	in robotics.
Skills	Students are able to derive and solve equations of motion for	various manipulators.		
	Students can generate trajectories in various coordinate systems.			
	Students can design linear and partially nonlinear controllers for robotic manipulators.			
Personal Competence				
Social Competence	Students are able to work goal-oriented in small mixed groups.			
Autonomy	Students are able to recognize and improve knowledge deficits independently.			
	With instructor assistance, students are able to evaluate their own knowledge level and define a further course of study.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Aircraft Systems Engineering: Core qualification: Elective Con	pulsory		
Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems	Elective Compulsory		
	International Management and Engineering: Specialisation II.	Mechatronics: Elective Compulsory		
	International Management and Engineering: Specialisation II.	•	on: Elective Co	ompulsory
	Mechanical Engineering and Management: Core qualification:	Compulsory		
	Mechatronics: Core qualification: Compulsory	n Draduck Davider		
	Product Development, Materials and Production: Specialisation	•	ompulsory	
	Product Development, Materials and Production: Specialisatio Product Development, Materials and Production: Specialisatio	• •		
	Theoretical Mechanical Engineering: Technical Complemental			
	Theoretical Mechanical Engineering: Technical Complemental Theoretical Mechanical Engineering: Specialisation Robotics a		nulsory	
	es. es.eur meeriamear Engineering. Specialisation Robotics a	computer science. Elective Con	.p 31301 y	

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

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

Courses				
Title		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and	Mechanics II (Hydrostatics, Kinematics, Dyn	amics)	
Knowledge	Mathematics I, II, III (in particular differential equa	ations)		
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge re overview of the theoretical and methodical basis		ent method and	are able to give
Skills	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations.			
	Students can work in small groups on specific pro	blems to arrive at joint solutions.		
Autonomy	The students are able to independently solve of Problems can be identified and the results are critical		acversp own min	e ciemene rouen
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ure 56		
Credit points	6			
Course achievement	Compulsory Bonus Form	Description		
course acmevement	No 20 % Midterm	·		
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Civil Engineering: Core qualification: Compulsory			
Following Curricula	Energy Systems: Core qualification: Elective Com	pulsory		
3	Aircraft Systems Engineering: Specialisation Aircr			
	Aircraft Systems Engineering: Specialisation Air T			
	Aircraft Systems Engineering: Core qualification:			
	International Management and Engineering: Spec		orv	
	International Management and Engineering: Spec			ompulsory
	Mechatronics: Core qualification: Compulsory	iansacion ii. I roduce Development and Produ	action. Liective Co	ompuisor y
		and Endonrosthosos: Compulsory		
	Biomedical Engineering: Specialisation Implants a		moulcor:	
	Biomedical Engineering: Specialisation Manageme			
	Biomedical Engineering: Specialisation Medical Te	echnology and Control Theory: Elective Com	puisory	
	Diamondinal Engineering, Constitution Action 1.0	seems and December 18 - 11 - 12 - 12 - 12	Camanulas :- :	
	Biomedical Engineering: Specialisation Artificial O		Compulsory	
	Biomedical Engineering: Specialisation Artificial O Product Development, Materials and Production: (Technomathematics: Specialisation III. Engineerin	Core qualification: Compulsory	Compulsory	

Course L0291: Finite Elemen	Course LO291: Finite Element Methods		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Otto von Estorff		
Language	EN		
Cycle	WiSe		
Content	- General overview on modern engineering		
	- Displacement method		
	- Hybrid formulation		
	- Isoparametric elements		
	- Numerical integration		
	- Solving systems of equations (statics, dynamics)		
	- Eigenvalue problems		
	- Non-linear systems		
	- Applications		
	- Programming of elements (Matlab, hands-on sessions)		
	- Applications		
Literature	Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin		

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

Module M0846: Contr	rol Systems Theory and Desig	yn		
Courses				
Title		Тур	Hrs/wk	СР
Control Systems Theory and Design		Lecture	2	4
Control Systems Theory and Design		Recitation Section (s	mall) 2	2
Module Responsible				
Admission Requirements				
	Introduction to Control Systems			
Knowledge				
Educational Objectives		ave reached the following learning results		
Professional Competence				
Knowledge Skills	 Students can explain how linear dynamic systems are represented as state space models; they can interpret the syster response to initial states or external excitation as trajectories in state space They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively They can explain the significance of a minimal realisation They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection They can extend all of the above to multi-input multi-output systems They can explain the z-transform and its relationship with the Laplace Transform They can explain state space models and transfer function models of discrete-time systems They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem cabe solved by solving a normal equation They can explain how a state space model can be constructed from a discrete-time impulse response 			
	Students can work in small groups on spe Students can obtain information from pr when solving given problems.			ent guides) and use
Monklood in House	Indonesia destructura Timo 124 Chindu Timo	in Lachura EG		
Credit points	Independent Study Time 124, Study Time	III Lecture 30		
Course achievement				
	Written exam			
Examination duration and	120 min			
scale				
-	Electrical Engineering: Core qualification:			
Following Curricula				
	Aircraft Systems Engineering: Core qualifi		ivo Compulsory	
		Specialisation II. Engineering Science: Electing: Specialisation II. Electrical Engineering:		
		ng: Specialisation II. Electrical Engineering: ng: Specialisation II. Mechatronics: Elective		
	-	:: Specialisation Mechatronics: Elective Cor		
	Mechatronics: Core qualification: Compuls	·		
	· · ·	tificial Organs and Regenerative Medicine:	Elective Compulsory	
		plants and Endoprostheses: Elective Comp	, ,	
		edical Technology and Control Theory: Com	•	
	Biomedical Engineering: Specialisation Ma	anagement and Business Administration: E	lective Compulsory	
	Product Development, Materials and Prod	uction: Core qualification: Elective Compul	sory	
	Theoretical Mechanical Engineering: Core	qualification: Compulsory		

Tvn	Lecture	
Hrs/wk		
	4 Independent Study Time 02 Study Time in Lecture 29	
	Independent Study Time 92, Study Time in Lecture 28	
	Prof. Herbert Werner	
Language		
Cycle		
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	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1222: Design and Implementation of Software Systems					
Courses	Courses				
Title		Тур	Hrs/wk	СР	
Design and Implementation of Soft		Lecture	2	3	
Design and Implementation of Soft	ware Systems (L1658)	Practical Course	2	3	
Module Responsible	NN				
Admission Requirements	None				
Recommended Previous	- Imperativ programming languages (C, Pascal,	Fortran or similar)			
Knowledge	- Simple data types (integer, double, char, book	ean), arrays, if-then-else, for, while, proce	dure and function call	İs	
Educational Objectives	After taking part successfully, students have re-	ached the following learning results			
Professional Competence					
Knowledge	Students are able to describe mechatronic system	ems and define requirements.			
Chille	Students are able to design and implement me	and the supplementation of the supplementatio	us the semplination of	Elland and Caffrigue	
Skills	and the interfaces.	echatronic systems. They are able to arg	ue the combination of	naiu- aliu soitwale	
Personal Competence					
Social Competence	Students are able to work goal-oriented in sma	II mixed groups, learning and broadening	teamwork abilities a	nd define task within	
	the team.				
Autonomy	Students are able to solve individually exercise	see related to this lecture with instructi	anal direction. Studen	ate are able to plan	
Autonomy	execute and summarize a mechatronic experim		onar direction. Studer	its are able to plaif,	
	execute and summarize a mechatronic experim	ient.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 min				
scale					
Assignment for the	Mechatronics: Core qualification: Compulsory				
Following Curricula					

	nplementation of Software Systems
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
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	

Module M0751: Vibra	tion Theory			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
	• Engineering Mechanics			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibra	tion 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 groups.			
Autonomy	Students are able to approach individually research task	s in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Energy Systems: Core qualification: Elective Compulsory			
Following Curricula	International Management and Engineering: Specialisati	on II. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management: Specialisation	Mechatronics: Elective Compulso	ry	
	Mechatronics: Core qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective	ve Compulsory	
	Biomedical Engineering: Specialisation Implants and Eng			
	Biomedical Engineering: Specialisation Medical Technology	**		
	Biomedical Engineering: Specialisation Management and		Compulsory	
	Product Development, Materials and Production: Core qu			
	Naval Architecture and Ocean Engineering: Core qualific			
	Theoretical Mechanical Engineering: Technical Complem	•	ry	
	Theoretical Mechanical Engineering: Core qualification: I	lective Compulsory		

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

Module M1211: Resea	arch Project Mechatronics
Courses	
Title	Typ Hrs/wk CP
Module Responsible	Dozenten des Studiengangs
Admission Requirements	None
Recommended Previous	Subjects of the program of studies.
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to demonstrate their detailed knowledge in the field of 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 engineering. They may apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science 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 these methods relate to the field of work and how the context of application has to be adjusted. General findings and further 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 for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0
Credit points	12
Course achievement	None
Examination	Study work
Examination duration and	It. FSPO
scale	
Assignment for the	Mechatronics: Core qualification: Compulsory
Following Curricula	

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: Approximation and Stability				
Courses				
Title Approximation and Stability (L0487 Approximation and Stability (L0488		Typ Lecture Recitation Section (small)	Hrs/wk 3 1	CP 4 2
Module Responsible	Prof. Marko Lindner			
Admission Requirements	None			
Recommended Previous Knowledge	Linear Algebra: systems of linear equations, lea Analysis: sequences, series, differentiation, inter		ular values	
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence Knowledge	Students are able to sketch and interrelate basic concepts of functio name and understand concrete approximation name and explain basic stability theorems, discuss spectral quantities, conditions numbers	methods,		
<i>Skills</i>	Students are able to apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities, apply regularisation methods.			
Personal Competence				
Social Competence	Students are able to solve specific problems in groups	and to present their results appropriat	ely (e.g. as a sem	inar presentation).
Autonomy	 Students are capable of checking their unders precisely and know where to get help in solving Students have developed sufficient persistenc problems. 	them.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points	6			
Course achievement	Compulsory Bonus Form De Yes None Presentation	scription		
Examination	Oral exam			
Examination duration and scale	20 min			
Assignment for the	Electrical Engineering: Specialisation Control and Pow	er Systems Engineering: Elective Comp	ulsory	
Following Curricula	Mechatronics: Specialisation Intelligent Systems and F Technomathematics: Specialisation I. Mathematics: El Theoretical Mechanical Engineering: Technical Comple Theoretical Mechanical Engineering: Specialisation Ro	ective Compulsory ementary Course: Elective Compulsory	Compulsory	

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

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

Module M0752: Nonlin	near 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			
	J 11 J 11 11			
	After taking part successfully, students have reached the fol	lowing 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 and
	concepts.			
Skills	Students are able to apply existing methods and procesures	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 individu	ally 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 Co	mpulsory		
Following Curricula	International Management and Engineering: Specialisation I	. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management: Specialisation Me	echatronics: Elective Compulso	ry	
	Mechatronics: Specialisation System Design: Elective Comp	ulsory		
	Mechatronics: Specialisation Intelligent Systems and Robotic	cs: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Electi	ve Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopr			
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Management and Bu	siness Administration: Elective	Compulsory	
	Product Development, Materials and Production: Core qualif			
	Theoretical Mechanical Engineering: Technical Complement	,	ry	
	Theoretical Mechanical Engineering: Core qualification: Elec	tive Compulsory		

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

Module M0714: Nume	erical Treatment of Ordinary Dif	ferential Equations		
Courses				
Title		Тур	Hrs/wk	СР
Numerical Treatment of Ordinary D	•	Lecture	2	3
Numerical Treatment of Ordinary D	·	Recitation Section (small)	2	3
Module Responsible	Prof. Daniel Ruprecht			
Admission Requirements	None			
Recommended Previous	Mathematik I. II. III für Ingenieurstudiere	ende (deutsch oder englisch) oder Analysis &	Lineare Algebra I	+ II sowie Analysis III
Knowledge	für Technomathematiker Basic MATLAB knowledge	(
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence		eached the following learning results		
•				
Knowieuge	Students are able to			
		of ordinary differential equations and explain t ne treated numerical methods (including the		ed to the underlying
	explain aspects regarding the practical	execution of a method.		
	select the appropriate numerical met interpret the numerical results	thod for concrete problems, implement the	numerical algori	thms efficiently and
Skills	Students are able to			
	implement (MATLAR), apply and compa	re numerical methods for the solution of ordina	ary differential eq	uations
	to justify the convergence behaviour of	numerical methods with respect to the posed solution approach, if necessary by the compos	problem and selec	cted algorithm,
Personal Competence Social Competence	Students are able to			
		posed teams (i.e., teams from different study port each other with practical aspects regarding		
Autonomy	Students are capable			
	to assess whether the supporting theory	etical and practical excercises are better solve	d individually or ir	n a team
	., -	if necessary, to ask questions and seek help.		
		ecture 30		
-				
		and Blanca and Franks 1 51 11 6		
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Following Curricula	, , , , , , , , , , , , , , , , , , , ,			
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		• •		
		, ,		
	Theoretical Mechanical Engineering: Core qual	• •		
	Process Engineering: Specialisation Chemical I	• •		
	Process Engineering: Specialisation Process Er	ngineering: Elective Compulsory		
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	students are able to work together in heterogeneously compexplain theoretical foundations and sup Students are capable to assess whether the supporting theore to assess their individual progress and, Independent Study Time 124, Study Time in Le None Written exam 90 min Bioprocess Engineering: Specialisation A - Gen Chemical and Bioprocess Engineering: Special Computer Science: Specialisation III. Mathema Electrical Engineering: Specialisation Control at Energy Systems: Core qualification: Elective C Aircraft Systems Engineering: Core qualification Interdisciplinary Mathematics: Specialisation II Mechatronics: Specialisation Intelligent System Technomathematics: Specialisation I. Mathem Theoretical Mechanical Engineering: Core qual Process Engineering: Specialisation Chemical I	cosed teams (i.e., teams from different study properties and practical excercises are better solve if necessary, to ask questions and seek help. The ecture 56 The ecture	orograms and bacing the implemental dindividually or in dindividually or in cory Compulsory Compulsory	kground knowle lition of algorithi

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

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

Courses				
Title		Тур	Hrs/wk	СР
Optimal and Robust Control (L0658 Optimal and Robust Control (L0659		Lecture Recitation Section (small)	2	3
Module Responsible		recreation Section (Small)		
Admission Requirements				
Recommended Previous				
Knowledge	Classical control (frequency response, root	locus)		
	State space methods Linear alrebra gianular value decomposition			
	 Linear algebra, singular value decomposition 	on		
Educational Objectives	After taking part successfully, students have reach	ned the following learning results		
Professional Competence				
Knowledge	 Students can explain the significance of the 	e matrix Riccati equation for the solution of	LO problems.	
	They can explain the duality between opting			
	They can explain how the H2 and H-infinity			traints.
	 They can explain how an LQG design proble 	em can be formulated as special case of an	H2 design proble	m.
	They can explain how model uncertainty can be a can			
	They can explain how - based on the smal	I gain theorem - a robust controller can gu	arantee stability	and performance
	an uncertain plant.They understand how analysis and synthes	is conditions on foodback loops can be ropr	acontod ac linoar	matrix inequalities
	• They understand now analysis and synthes	is conditions on reedback loops can be repri	esented as iniear	matrix mequalities
Skills	Students are capable of designing and tuni	ng LOG controllers for multivariable plant m	odels	
	They are capable of representing a H2 or H			and of using standa
	software tools for solving it.	, , ,		J
	 They are capable of translating time and f 	requency domain specifications for control	loops into const	raints on closed-lo
	sensitivity functions, and of carrying out a r	mixed-sensitivity design.		
	They are capable of constructing an LFT in the capable of constructing and LFT in the capable of	uncertainty model for an uncertain system	, and of designing	ng a mixed-objecti
	robust controller.	and a such a sign and distance on the same assets to a		
	 They are capable of formulating analysis a LMI-solvers for solving them. 	nd synthesis conditions as linear matrix me	equalities (LMI), a	ind of using standa
	They can carry out all of the above using st	andard software tools (Matlab robust contro	ol toolbox).	
Personal Competence	Charles to a second in second			
Social Competence Autonomy	Students can work in small groups on specific pro		oftware decume	ntation) and use it
Autonomy	Students are able to find required information in solve given problems.	sources provided (lecture notes, literature, s	software docume	nitation) and use it
	solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ire 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Control and	Power Systems Engineering: Elective Comp	ulsory	
Following Curricula	Energy Systems: Core qualification: Elective Comp	pulsory		
. S.	Aircraft Systems Engineering: Core qualification: E	Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems a			
	Mechatronics: Specialisation System Design: Elect	, ,		
	Biomedical Engineering: Specialisation Artificial O	· ·	Compulsory	
	Biomedical Engineering: Specialisation Implants a Biomedical Engineering: Specialisation Medical Te		nulsony	
	Biomedical Engineering: Specialisation Medical Te Biomedical Engineering: Specialisation Manageme	**		
	Product Development, Materials and Production: S			
	Product Development, Materials and Production: S			
	Product Development, Materials and Production: S			
	Theoretical Mechanical Engineering: Technical Co	mplementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualifica	ation: Elective Compulsory		

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

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

Module M1156: Syste	ems Engineering	
Courses		
Title	Typ Hrs/wk CP	•
Systems Engineering (L1547)	Lecture 3 4	
Systems Engineering (L1548)	Recitation Section (large) 1 2	
Module Responsible		
Admission Requirements	s None	
Recommended Previous		
Knowledge		
	• Mechanics	
	Thermodynamics Statistical Equipment	
	Electrical Engineering Carbon Control	
	Control Systems	
	Previous knowledge in:	
	Aircraft Cabin Systems	
Educate 1611 C	After the live of the second fills wheel the large was the data of the second file.	
Educational Objectives		
Professional Competence		
Knowledge	e Students are able to:	
	understand systems engineering process models, methods and tools for the development of complex Systems	
	describe innovation processes and the need for technology Management which the place of the second of th	
	explain the aircraft development process and the process of type certification for aircraft explain the aircraft development process including requirements for aircraft	
	explain the system development process, including requirements for systems reliability identify environmental conditions and test procedures for airborne Equipment	
	value the methodology of requirements-based engineering (RBE) and model-based requirements engineering (MBRE)	E)
	* value the methodology of requirements-based engineering (NDL) and moder-based requirements engineering (MDNL)	L)
Skills	s Students are able to:	
	• plan the process for the development of complex Systems	
	organize the development phases and development Tasks	
	assign required business activities and technical Tasks	
	apply systems engineering methods and tools	
Personal Competence	4	
•	e Students are able to:	
Social competence	 understand their responsibilities within a development team and integrate themselves with their role in the overall p 	process
	and stand their responsionates main a development team and integrate themselves main their role in the ordinal p	p. 0 c c 5 5
Autonomy	y Students are able to:	
	interact and communicate in a development team which has distributed tasks	
Workload in Hours	s Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement		
Examination duration and	1 Written exam	
scale		
Following Curricula	Aircraft Systems Engineering: Core qualification: Compulsory	
ronowing curricula	International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsor	orv
	Mechatronics: Specialisation System Design: Elective Compulsory	о. у
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory	
	Product Development, Materials and Production: Specialisation Product Development: Compulsory	
	Product Development, Materials and Production: Specialisation Production: Elective Compulsory	
	Product Development, Materials and Production: Specialisation Materials: Elective Compulsory	
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory	
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Course L1547: Systems Engineering		
Тур	Lecture	
Hrs/wk	3	
СР	4	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content	The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integration of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineering process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known. Key aspects of the course are processes for innovation and technology management, system design, system integration and	
	certification as well as tools and methods for systems engineering: Innovation processes IP-protection Technology management Systems engineering Aircraft program Certification issues Systems development Safety objectives and fault tolerance Environmental and operating conditions Tools for systems engineering Requirements-based engineering (RBE) Model-based requirements engineering (MBRE)	
Literature	- Skript zur Vorlesung - diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE) - Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010 - NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007 - Hinsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation luftfahrttechnischer Betriebe. Springer, 2010 - De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010 - Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt. Verlag, 2008	

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

Module M1212: Technical Complementary Course for IMPMEC (according to Subject Specific Regulations)		
Courses		
Title	Typ Hrs/wk CP	
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	
Autonomy	see selected module according to FSPO	
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	

Module M1223: Selec	ted Topics of Mechatronics (Alterna	tive A: 12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Applied Automation (L1592)			3	3
Ergonomics (L0653)		Lecture	2	3
Advanced Training Course SE-ZER	T (L2739)	Project-/problem-based Learning	2	3
Development Management for Med	chatronics (L1512)	Lecture	2	3
Fatigue & Damage Tolerance (L03)	10)	Lecture	2	3
Industry 4.0 for engineers (L2012)		Lecture	2	3
Microcontroller Circuits: Implement	tation 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
Process Measurement Engineering	(L1077)	Lecture	2	3
Process Measurement Engineering	(L1083)	Recitation Section (large)	1	1
Feedback 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 reache	d the following learning results		
Professional Competence				
Knowledge				
	Students are able to express their extended	knowledge and discuss the connection of di	fferent specia	il fields or application
	areas of mechatronics			
	 Students are qualified to connect different spen 	ecial fields with each other		
Skills				
Skiiis	 Students can apply specialized solution strate 	egies and new scientific methods in selected	areas	
	Students are able to transfer learned skills to	new and unknown problems and can develop	p own solution	n approaches
Personal Competence				
Social Competence	None			
Autonomy		and skills by autonomous election of severe	c	
	Students are able to develop their knowledge	and skins by autonomous election of course.	5.	
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the	Mechatronics: Specialisation System Design: Elective	e Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and	I Dalastina Elastina Camandana		

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
Literature	-Project Based Learning -Robot Operating System -Robot structure and description -Motion description -Calibration -Accuracy 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
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
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	120 min
scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der
	deutschen Übersetzung), ISBN 978-3-9818805-0-2.
	ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System
	Life Cycle Processes).

Course L1512: Development	Management for Mechatronics
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 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 morgen 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
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	45 min
scale	
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve
	fatigue strength, environmental influences
Literature	Jaap Schijve, Fatigue of Structures and Materials. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit
	Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989

Course L2012: Industry 4.0 for engineers	
Тур	Lecture
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. Thorsten Schüppstuhl
Language	DE
Cycle	SoSe
Content	
Literature	

Course L0087: Microcontroller Circuits: Implementation in Hardware and Software	
Тур	Seminar
Hrs/wk	2
СР	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	s Technology
	Lecture
Hrs/wk	
CP	
	Independent Study Time 92, Study Time in Lecture 28
Examination Form	
Examination duration and	
scale	
	Prof. Hoc Khiem Trieu
Language	
Cycle	
Content	
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, anao-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, SUB, 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 sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas 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 conductiv
	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

Course L1551: Model-Based	Systems Engineering (MBSE) with SysML/UML
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung
Examination duration and	ca. 10 Seiten
scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe 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

Course L1077: Process Meas	urement Engineering
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	45 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	Färbar, Draya (rachante shail: "Caringar Varlag 1004
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:	
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 Dynai	mics
Тур	Lecture
Hrs/wk	2
СР	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 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 M1224: Selec	ted Topics of Mechatronics (Alternati	ive B: 6 LP)		
Courses				
Title		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 Mechatronics (L1512)		Lecture	2	3
Fatigue & Damage Tolerance (L031	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
Process Measurement Engineering	(L1077)	Lecture	2	3
Process Measurement Engineering	(L1083)	Recitation Section (large)	1	1
Feedback 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	Charles to a sold to a suppose the first transfer dead law	and the second ofference blood and the second of the secon	ee	l fielde en endieskien
	Students are able to express their extended kn	nowleage and discuss the connection of di	merent specia	i neids or application
	areas of mechatronics			
	 Students are qualified to connect different spec 	ial fields with each other		
Skills				
Skills	 Students can apply specialized solution strategi 	ies and new scientific methods in selected	areas	
	Students are able to transfer learned skills to not	ew and unknown problems and can develop	p own solutio	n approaches
Personal Competence				
	None			
Social Competence	None			
Autonomy	Students are able to develop their knowledge a	nd skills by autonomous election of course	S.	
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 R	Robotics: Elective Compulsory		

Course L1592	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
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 Training Course SE-ZERT		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	120 min	
scale		
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content		
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der	
	deutschen Übersetzung), ISBN 978-3-9818805-0-2.	
	ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System	
	Life Cycle Processes).	

Course L1512: Development Management for Mechatronics		
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 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 morgen 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	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	45 min	
scale		
Lecturer	Dr. Martin Flamm	
Language	EN	
Cycle	WiSe	
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve	
	fatigue strength, environmental influences	
Literature	Jaap Schijve, Fatigue of Structures and Materials. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkei	
	Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989	

Course L2012: Industry 4.0 for engineers	
Тур	Lecture
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. Thorsten Schüppstuhl
Language	DE
Cycle	SoSe
Content	
Literature	

Course L0087: Microcontroller Circuits: Implementation in Hardware and Software			
Тур	Seminar		
Hrs/wk	2		
СР	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	s Technology				
	Lecture				
Hrs/wk					
CP					
	ndependent Study Time 92, Study Time in Lecture 28				
Examination Form					
Examination duration and	-				
scale	חוווו ע				
	Prof. Hoc Khiem Trieu				
Language					
Cycle					
Content					
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, SOI, SCREAM process, LIGA, SUB, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: sterim resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensors (strain based and stress based principle 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; accelerometer: piezoresistive, piezoelectric and capacitive: angular rate sensors: magneto resistance, ANR 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,				
	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				

Course L1551: Model-Based	Systems Engineering (MBSE) with SysML/UML				
Тур	Project-/problem-based Learning				
Hrs/wk	3				
СР	3				
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42				
Examination Form	Schriftliche Ausarbeitung				
Examination duration and	ca. 10 Seiten				
scale					
Lecturer	Prof. Ralf God				
Language	DE				
Cycle	SoSe 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				

Course L1077: Process Meas	urement Engineering				
Тур	Lecture				
Hrs/wk	2				
СР	3				
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28				
Examination Form	Mündliche Prüfung				
Examination duration and	-				
scale					
Lecturer	Prof. Roland Harig				
Language	DE/EN				
Cycle	SoSe				
Content	Dracess measurement angineering in the context of process central engineering				
	 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	dependent 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. 			

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Course L1630: Applied Dynai	mics			
Тур	Lecture			
Hrs/wk				
СР	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 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				
Courses				
Title	Түр	Hrs/wk	СР	
Lab Cyber-Physical Systems (L1740)	· · · · · · · · · · · · · · · · · · ·	4	6	
Module Responsible Pro				
Admission Requirements Nor				
Recommended Previous Mod				
Knowledge				
Educational Objectives After	er taking part successfully, students have reached the following learning results			
Professional Competence				
actis a Basslab hier	Cyber-Physical Systems (CPS) are tightly integrated with their surrounding environment, via sensors, A/D and D/A converters, and actors. Due to their particular application areas, highly specialized sensors, processors and actors are common. Accordingly, there is a large variety of different specification approaches for CPS - 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. The lab introduces into the area (basic notions, characteristical properties) and their specification techniques (models of computation, hierarchical automata, data flow models, petri nets, imperative approaches). Since CPS frequently perform control tasks, the lab's experiments will base on simple control applications. The experiments will use state-of-the-art industrial specification tools (MATLAB/Simulink, LabVIEW, NXC) in order to model cyber-physical models that interact with the environment via sensors and actors.			
CPS digi adv to p	er successful attendance of the lab, students are able to develop simple CPS. They understand to and its surrounding processes which stem from the fact that a CPS interacts with the environmental processors, D/A converters and actors. The lab enables students to compare modelling vantages and limitations, and to decide which technique to use for a concrete task. They will be practical problems. They obtain first experiences in hardware-related software development, it and in the area of simple control applications.	ment via sensors g approaches, to be able to apply	s, A/D converters, to evaluate their these techniques	
Personal Competence				
Social Competence Stu	idents are able to solve similar problems alone or in a group and to present the results according	ngıy.		
<i>Autonomy</i> Stu	idents are able to acquire new knowledge from specific literature and to associate this knowledge	ge with other cla	asses.	
Workload in Hours Ind	ependent Study Time 124, Study Time in Lecture 56			
Credit points 6				
Course achievement Nor	***			
Examination Wri				
	ecution and documentation of all lab experiments			
Scale	noral Engineering Science (Cormon program, 7 competent). Considering Competent Science El-	octivo Commul	n.	
-	neral Engineering Science (German program, 7 semester): Specialisation Computer Science: Ele mputer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory	ective Compulso	ту	
-	mputer Science: Specialisation ii. Mathematics and Engineering Science: Elective Compulsory mputer Science: Specialisation Computer and Software Engineering: Elective Compulsory			
	neral Engineering Science (English program, 7 semester): Specialisation Computer Science: Elec	ctive Compulsor	v	
	mputational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elec mputational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Ele	•	-	
	chatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory	cave compuisor	J	
	chatronics: Specialisation intelligent Systems and Robotics, Elective Compulsory			
	chatronics: Technical Complementary Course: Elective Compulsory			

Course L1740: Lab Cyber-Phy	ysical Systems
Тур	Project-/problem-based Learning
Hrs/wk	4
СР	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

Carriera				
Courses		_		
Title Applied Humanoid Robotics (L1794		Typ Project-/problem-based Learning	Hrs/wk 6	CP 6
Module Responsible	Patrick Göttsch	rroject/problem basea zeaming		
Admission Requirements	None			
Recommended Previous Knowledge	Object oriented programming; algorithms and data struct Introduction to control systems Control systems theory and design Mechanics	tures		
Educational Objectives	After taking part successfully, students have reached the follow	ing 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 o other tasks. They are capable of using models in Matlab for simulation and testing these models if necessary with C++ code on the real robot system. They are capable of selecting methods for solving abstract problems, for which no standard methods are available, and apply it successfully. 			
Personal Competence Social Competence Autonomy	 Students can develop joint solutions in mixed teams and They can provide appropriate feedback to others, and co Students are able to obtain required information from lecture. They can independently define tasks and apply the approximation. 	onstructively handle feedback on provided literature sources, and		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	5-10 pages			
scale				
Assignment for the	Computer Science: Specialisation II: Intelligence Engineering: El	, ,		
Following Curricula	Electrical Engineering: Specialisation Control and Power System		ory	
	Mechatronics: Specialisation Intelligent Systems and Robotics: E		laam.	
	Theoretical Mechanical Engineering: Specialisation Bio- and Mec		іѕогу	
	Theoretical Mechanical Engineering: Technical Complementary Theoretical Mechanical Engineering: Specialization Reportice and		anulcor.	
	Theoretical Mechanical Engineering: Specialisation Robotics and	i Computer Science: Elective Com	npulsory	

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

Module M1306: Contr	rol Lab C				
1100001011125001001111					
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	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	State space methods				
Knowledge	LQG control				
	H2 and H-infinity optimal control				
	 uncertain plant models and robust control 				
	LPV control				
Educational Objectives	After taking part successfully, students have reac	ned the following learning results			
Professional Competence	3,4	3 3			
Knowledge					
j .	Students can explain the difference between	n validation of a control lop in simulation	n and experimental v	validation	
Skills					
	• Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a				
	dynamic model that can be used for controller synthesis				
	They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG				
	controllers				
	They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the				
	implementation of H-infinity optimal controllers				
	They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlah Bobust Control Toolbox) for the design and the implementation of				
	They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain scheduled controllers.				
	LPV gain-scheduled controllers				
Personal Competence					
Social Competence					
	 Students can work in teams to conduct exp 	eriments and document the results			
Autonomy					
	Students can independently carry out simu	lation studies to design and validate con	trol loops		
Workload in Hours	Independent Study Time 48, Study Time in Lectur	e 42			
Credit points	3				
Course achievement	None				
Examination					
Examination duration and	1				
scale					
	Electrical Engineering: Specialisation Control and		mpulsory		
Following Curricula	, , , , , , , , , , , , , , , , , , , ,				
	Mechatronics: Specialisation System Design: Elect				
	Theoretical Mechanical Engineering: Core qualification	, ,			
	Theoretical Mechanical Engineering: Technical Co	mpiementary Course: Elective Compulso	ry		

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

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

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

Module M1281: Advanced Topics in Vibration				
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 foll	owing learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts of Advance	ed Vibrations and to develop and resea	arch new terms	and concepts.
Skills	Students are able to apply existing methods and procesures of Adv	vanced 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 an	d to identify and follow up novel resear	rch tasks by the	mselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Mechatronics: Specialisation System Design: Elective Compu	Isory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics	s: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective Co	mpulsory		
	Theoretical Mechanical Engineering: Technical Complementa	ry Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Product D	evelopment and Production: Electiv	e Compulsory	

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

Module M0835: Huma	noid Robotics			
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			
	Control theory and design			
	control allesty and design			
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	Students can explain humanoid robots.			
	Students learn to apply basic control conce	epts for different tasks in humanoid ro	botics.	
Skills				
SKIIIS	Students acquire knowledge about selecter	d aspects of humanoid robotics, based	d on specified literature	
	 Students generalize developed results and 	present them to the participants		
	Students practice to prepare and give a pre-	esentation		
Personal Competence				
Social Competence				
,	Students are capable of developing solutio			
	 They are able to provide appropriate feedb 	ack and handle constructive criticism	of their own results	
Autonomy	Charles and a second discoul	and the second forms of management	ti f	
	 Students evaluate advantages and drawlessell solution 	backs of different forms of presenta	tion for specific tasks	and select the best
	Students familiarize themselves with a sc	ientific field, are able of introduce it	and follow presentation	s of other students
	such that a scientific discussion develops	remaine meta, are able of merodate it	and ronon presentation	or outer bedderies,
	·			
Workload in Hours	Independent Study Time 32, Study Time in Lectur	re 28		
Credit points				
Course achievement				
Examination	30 min			
Examination duration and scale	30 min			
Assignment for the	Mechatronics: Specialisation Intelligent Systems a	and Robotics: Flective Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems a Mechatronics: Specialisation System Design: Elec			
	Biomedical Engineering: Specialisation Artificial O		ective Compulsory	
	Biomedical Engineering: Specialisation Implants a			
	Biomedical Engineering: Specialisation Medical Te			
	Biomedical Engineering: Specialisation Manageme	ent and Business Administration: Elec	tive Compulsory	
	Theoretical Mechanical Engineering: Technical Co	mplementary Course: Elective Compu	ulsory	
	Theoretical Mechanical Engineering: Specialisatio	n Robotics and Computer Science: Ele	ective Compulsory	

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

Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Ident	ification (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	Classical control (frequency respo State space methods Discrete-time systems Linear algebra, singular value dec Basic knowledge about stochastic	romposition		
Educational Objectives	After taking part successfully, students h	nave reached the following learning results		
Professional Competence	3.			
Skills Personal Competence Social Competence Autonomy	 Students can explain the general framework of the prediction error method and its application to a variety of linear and nonlinear model structures They can explain how multilayer perceptron networks are used to model nonlinear dynamics They can explain how an approximate predictive control scheme can be based on neural network models They can explain the idea of subspace identification and its relation to Kalman realisation theory Students are capable of applying the predicition error method to the experimental identification of linear and nonlinear models for dynamic systems They are capable of implementing a nonlinear predictive control scheme based on a neural network model They are capable of applying subspace algorithms to the experimental identification of linear models for dynamic systems They can do the above using standard software tools (including the Matlab System Identification Toolbox) 			
	solve given problems.			
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Co.	ntrol and Power Systems Engineering: Elective	e Compulsory	
Following Curricula	Mechatronics: Specialisation System Des Biomedical Engineering: Specialisation A Biomedical Engineering: Specialisation In Biomedical Engineering: Specialisation M	urtificial Organs and Regenerative Medicine: El mplants and Endoprostheses: Elective Compul Medical Technology and Control Theory: Comp Management and Business Administration: Elec	lsory ulsory ctive Compulsory	

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

Module M0939: Contr	ol Lab A			
Courses				
Title Control Lab I (L1093) Control Lab II (L1291) Control Lab III (L1665) Control Lab IV (L1666)		Typ Practical Course Practical Course Practical Course Practical Course	Hrs/wk 1 1 1	CP 1 1 1
Module Responsible	Prof. Herbert Werner			
Admission Requirements Recommended Previous Knowledge	None • 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 reac	hed the following learning results		
Professional Competence Knowledge	Students can explain the difference between	en validation of a control lop in simulation	n and experimental v	alidation
Skills	 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers 			
Personal Competence Social Competence	Students can work in teams to conduct exp.	eriments and document the results		
Autonomy	Students can independently carry out simu	lation studies to design and validate con	trol loops	
Workload in Hours	Independent Study Time 64, Study Time in Lectur	e 56		
Credit points				
Course achievement				
Examination				
Examination duration and scale				
	Electrical Engineering: Specialisation Control and	Power Systems Engineering: Elective Co	mpulsorv	
Following Curricula				
	Mechatronics: Specialisation Intelligent Systems a	nd Robotics: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Co	mplementary Course: Elective Compulso	ry	
	Theoretical Mechanical Engineering: Specialisation	n Robotics and Computer Science: Election	ve Compulsory	

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

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

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

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

Module M0924: Softw	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 (small)	3	3
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous Knowledge	Good knowledge and experience in prograr Basis knowledge in software engineering Basic understanding of assembly language	nming language C		
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
	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 concrete microcontroller. The participants explain requirements of real time systems. They know at least three scheduling algorithms for real time operating systems including their pros and cons. Students build interrupt-based programs for a concrete microcontroller. They build and use a preemptive scheduler. They use peripheral components (timer, ADC, EEPROM) to realize complex tasks for embedded systems. To interface with external components they utilize serial protocols.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 110, Study Time in Lectu	ire 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Mechatronics: Technical Complementary Course:	Elective Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems a	nd Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elect	ive Compulsory		
	Microelectronics and Microsystems: Specialisation	Embedded Systems: Elective Compulso	ry	

Course L1069: Software for I	
	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 Embdedded Systems	
Тур	Recitation Section (small)
Hrs/wk	3
СР	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				
Γitle		Тур	Hrs/wk	СР
Compilers for Embedded Systems (Lecture	3	4
Compilers for Embedded Systems (L1693)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Heiko Falk			
Admission Requirements	None			
Recommended Previous	Module "Embedded Systems"			
Knowledge	C/C++ Programming skills			
Educational Objectives	After taking part successfully, students have reach	ned 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 executed or embedded processors grows continuously due to its lower costs and higher flexibility. Because of the particular application areas of embedded systems, highly optimized and application-specific processors are deployed. Such highly specialized processor impose high demands on compilers which have to generate code of highest quality. After the successful attendance of this course the students are able • to illustrate the structure and organization of such compilers, • to distinguish and explain intermediate representations of various abstraction levels, and			
	 to assess optimizations and their underlying The high demands on compilers for embedded particular, 		mandatory. Tl	he students learn
	which kinds of optimizations are applicable how the translation from source code to ass which kinds of optimizations are applicable how register allocation is performed, and how memory hierarchies can be exploited e Since compilers for embedded systems often have energy dissipation, code size), the students learn t	sembly code is performed, at the assembly code level, effectively. e to optimize for multiple objectives (e.g., ave		
Skills	After successful completion of the course, student be enabled to assess which kind of code optimizat assembly code) within a compiler. While attending the labs, the students will learn to	tion should be applied most effectively at wh	ich abstraction	level (e.g., source
Personal Competence	Students are able to solve similar problems along	or in a group and to proceed the recults assess	dingly	
•	Students are able to solve similar problems alone Students are able to acquire new knowledge from			er classes.
Workload in Hours	Independent Study Time 124, Study Time in Lectu			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale	50 mm			
	Computer Science: Specialisation I. Computer and	Software Engineering: Flective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Information a		lsorv	
i onowing curricula	Aircraft Systems Engineering: Core qualification: E	·	11301 y	
	Mechatronics: Specialisation Intelligent Systems a	• •		
	Mechatronics: Specialisation System Design: Election			
	Mechatronics: Specialisation System Design: Election Mechatronics: Technical Complementary Course: E	•		
	Theoretical Mechanical Engineering: Technical Cor			
		p.cciitary Course. Elective Compuisory		

Course L1692: Compilers for	Embedded Systems
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Heiko Falk
Language	DE/EN
Cycle	SoSe
Content	 Introduction and Motivation Compilers for Embedded Systems - Requirements and Dependencies Internal Structure of Compilers Pre-Pass Optimizations HIR Optimizations and Transformations Code Generation LIR Optimizations and Transformations Register Allocation WCET-Aware Compilation Outlook
Literature	 Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 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	ourse L1693: Compilers for Embedded Systems		
Тур	Project-/problem-based Learning		
Hrs/wk	1		
СР	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Heiko Falk		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0630: Robot	tics and Naviga	tion in Medicine			
Courses					
Title			Тур	Hrs/wk	СР
Robotics and Navigation in Medicin	e (L0335)		Lecture	2	3
Robotics and Navigation in Medicin			Project Seminar	2	2
Robotics and Navigation in Medicin	e (L0336)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schla	efer			
Admission Requirements	None				
Recommended Previous		-th (-1h hi-t1			
Knowledge		ath (algebra, analysis/cal			
		rogramming, e.g., in Java	01 C++		
	solid R or Matl	dD SKIIIS			
Educational Objectives	After taking part succ	cessfully, students have re	eached the following learning results		
Professional Competence					
Knowledge	The students can ex	plain kinematics and tra	cking systems in clinical contexts and illus	trate systems and	their components in
	detail. Systems can	be evaluated with respe	ct to collision detection and safety and re	egulations. Student	s can assess typica
	systems regarding de	esign and limitations.			
Ckilla	The students are able		and action systems and achatic systems for a	andinal annlinations	
SKIIIS	The students are able	e to design and evaluate r	navigation systems and robotic systems for r	nedical applications	5.
Personal Competence					
Social Competence	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work.				
Autonomy	The students can ref	lect their knowledge and	document the results of their work. They ca	an present the resu	ılts in an appropriate
	manner.				
Workload in Hours	Indonesia ont Childre	ina a 110. Church Linna in La	seture 70		
Credit points	6	ime 110, Study Time in Le	ecture 70		
Course achievement	Compulsory Bonus	Form	Description		
Course achievement	Yes 10 %	Written elaboration			
	Yes 10 %	Presentation			
Examination	Written exam				
Examination duration and	90 minutes				
scale					
Assignment for the	Computer Science: S	pecialisation II: Intelligend	e Engineering: Elective Compulsory		
Following Curricula	Electrical Engineering	g: Specialisation Medical T	echnology: Elective Compulsory		
	International Manage	ment and Engineering: Sp	pecialisation II. Electrical Engineering: Electiv	e Compulsory	
	International Manage	ment and Engineering: Sp	pecialisation II. Process Engineering and Bioto	echnology: Elective	Compulsory
	Mechatronics: Specia	lisation Intelligent System	ns and Robotics: Elective Compulsory		
	Biomedical Engineeri	ng: Specialisation Artificia	l Organs and Regenerative Medicine: Electiv	e Compulsory	
	Biomedical Engineeri	ng: Specialisation Implant	s and Endoprostheses: Elective Compulsory		
	Biomedical Engineeri	ng: Specialisation Medica	Technology and Control Theory: Elective Co	mpulsory	
	Biomedical Engineeri	ng: Specialisation Manage	ement and Business Administration: Elective	Compulsory	
	Product Developmen	t, Materials and Productio	n: Specialisation Product Development: Elect	ive Compulsory	
	-		n: Specialisation Production: Elective Compu		
	•		n: Specialisation Materials: Elective Compuls	•	
			Complementary Course: Elective Compulsor		
	Theoretical Mechanic	al Engineering: Specialisa	tion Bio- and Medical Technology: Elective C	ompulsory	

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.
<u>I</u>	

Course L0338: Robotics and	Course 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	Course L0336: Robotics and Navigation in Medicine	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0803: Embe	dded Systems			
Courses				
Courses				
Title		Тур	Hrs/wk	CP
Embedded Systems (L0805) Embedded Systems (L0806)		Lecture Recitation Section (small)	3 1	4
	Prof. Heiko Falk	Recitation Section (Small)		2
Module Responsible Admission Requirements				
Recommended Previous	Computer Engineering			
Knowledge	computer Engineering			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence	Arter taking part successivily, students have reached the	Tollowing learning results		
-	Embedded systems can be defined as information proce	ssing systems embedded into enclo	sing products. This	course teaches the
Knowledge	foundations of such systems. In particular, it deals with			
	their specification languages (models of computation,			
	specification of real-time applications, translations between			, gp,
	Another part covers the hardware of embedded syste	ms: Sonsors, A/D and D/A convert	ers, real-time cap	able communication
	hardware, embedded processors, memories, energy dis	sipation, reconfigurable logic and a	actuators. The cou	rse also features an
	introduction into real-time operating systems, middlew	are and real-time scheduling. Fina	lly, the implement	tation of embedded
	systems using hardware/software co-design (hardware/s	oftware partitioning, high-level trai	nsformations of sp	ecifications, energy-
	efficient realizations, compilers for embedded processors	s) is covered.		
Skills	After having attended the course, students shall be ab	e to realize simple embedded syst	rems. The student	s shall realize which
Skiiis	relevant parts of technological competences to use in o	•		
	able to compare different models of computations and f			
	which areas of embedded system design specific risks ex			,,,,,
Personal Competence				
Social Competence	Students are able to solve similar problems alone or in a	group and to present the results ac	cordingly.	
Autonomy	Students are able to acquire new knowledge from specifi	c literature and to associate this kn	owledge with other	r classes.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Descri	ption		
	Yes 10 % Subject theoretical and			
	practical work			
Examination				
	90 minutes, contents of course and labs			
scale	Concret Francisco Coiones (Correspondentes 7 anno 1	ton). Consisting Commuter Coins	an Commulari	
	General Engineering Science (German program, 7 semes		ce: Compulsory	
Following Curricula	Computer Science: Specialisation Computer and Softwar Computer Science: Specialisation I. Computer and Softwar			
	Electrical Engineering: Core qualification: Elective Computer		у	
	Engineering Science: Specialisation Mechatronics: Elective	•		
	Aircraft Systems Engineering: Core qualification: Elective			
	General Engineering Science (English program, 7 semest		ective Compulsory	
	Computational Science and Engineering: Core qualification	•	, ,	
	Mechatronics: Specialisation System Design: Elective Co			
	Mechatronics: Specialisation Intelligent Systems and Rob			
	Mechatronics: Core qualification: Elective Compulsory			
	Microelectronics and Microsystems: Specialisation Ember	dded Systems: Elective Compulsory		

Course L0805: Embedded Sy	stems
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Heiko Falk
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 Systems		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	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	

Module M0565: Mech	atronic System	S				
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)			I	Project-/problem-based Learning	2	2
Module Responsible	NN					
Admission Requirements	None					
Recommended Previous	Fundamentals of med	hanics, electromechanics	and control theory	•		
Knowledge						
Educational Objectives	After taking part succ	essfully, students have re	eached the following	g learning results		
Professional Competence						
Knowledge	Students are able to	describe methods and c	calculations to design	gn, model, simulate and optim	ize mechatro	nic systems and can
	repeat methods to ve	rify and validate models.				
Skills	Students are able to	plan and execute mech	atronic experiment	s. Students are able to model	mechatronic	systems and derive
	simulations and optim	nizations.				
Personal Competence						
Social Competence	Students are able to	Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities and define task within				
	the team.					
	6					
Autonomy	Students are able to s	solve individually exercise	es related to this led	cture with instructional direction	٦.	
	Students are able to p	olan, execute and summa	arize a mechatronic	experiment.		
Workload in Hours		me 110, Study Time in Le	ecture 70			
Credit points		_				
Course achievement	Compulsory Bonus	Form Subject theoretical	Description			
	Yes None	Subject theoretical practical work	and			
Examination	Writton ovam	practical work				
Examination duration and						
scale	30 IIIII					
	Mechatronics: Specia	lisation Intelligent System	ns and Robotics: Fle	ective Compulsory		
-	•	lisation System Design: E		• •		
Following Curricula	mechanionics. Special	iisation system besign. E	lective Compulsory			

Course L0174: Electro- and C	Contromechanics
Тур	Lecture
Hrs/wk	2
СР	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	Course 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
СР	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® RTW
Literature	- Abhängig vom Versuchsaufbau
	- Depends on the experiment

Module MU627: Mach	ine Learning and Data Mining			
Courses				
Fitle Machine Learning and Data Mining Machine Learning and Data Mining		Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 4 2
Module Responsible		,		
Admission Requirements	None			
Recommended Previous	None			
Knowledge	CalculusStochastics			
Educational Objectives	After taking part successfully, students have reach	ned the following learning results		
Professional Competence				
	Students can explain the difference between instance-based and model-based learning approaches, and they can enumerate basic machine learning technique for each of the two basic approaches, either on the basis of static data, or on the basis of incrementally incoming data. For dealing with uncertainty, students can describe suitable representation formalisms, and they explain how axioms, features, parameters, or structures used in these formalisms can be learned automatically with different algorithms. Students are also able to sketch different clustering techniques. They depict how the performance of learned classifiers can be improved by ensemble learning, and they can summarize how this influences computational learning theory. Algorithms for reinforcement learning can also be explained by students. Student derive decision trees and, in turn, propositional rule sets from simple and static data tables and are able to name and explain basic optimization techniques. They present and apply the basic idea of first-order inductive leaning. Students apply the BME, MAP, ML, and EM algorithms for learning parameters of Bayesian networks and compare the different algorithms. They also know how to carry out Gaussian mixture learning. They can contrast kNN classifiers, neural networks, and support vector machines, and name their basic application areas and algorithmic properties. Students can describe basic clustering techniques and explain the basic components of those techniques. Students compare related machine learning techniques, e.g., k-means clustering and nearest neighbor classification. They can distinguish various ensemble learning techniques and compare the different goals of those techniques.			
Personal Competence				
Social Competence				
Autonomy	Independent Charles Times 124 Charles T			
Workload in Hours	Independent Study Time 124, Study Time in Lecture	16 20		
Credit points Course achievement	6 None			
Examination	Written exam			
Examination duration and	90 minutes			
scale	Computer Calance, Consisting to Let-	naine evina. Fleekiye Commuleen		
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence El International Management and Engineering: Speci		e Compulsory	
i onowing curricula	Mechatronics: Technical Complementary Course: E		c compaisory	
	Mechatronics: Specialisation System Design: Elect			
	Mechatronics: Specialisation Intelligent Systems at			
		· · · · · · · · · · · · · · · · · · ·		
	Theoretical Mechanical Engineering: Technical Cor	mplementary Course: Elective Compulsory		

Course L0340: Machine Learning and Data Mining		
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, 14, 18-21 Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press 2012 	

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	Typ Hrs/wk CP
Digital Image Analysis (L0126)	Lecture 4 6
Module Responsible	Prof. Rolf-Rainer Grigat
Admission Requirements	None
Recommended Previous	System theory of one-dimensional signals (convolution and correlation, sampling theory, interpolation and decimation, Fourier
Knowledge	
	(expectation values, influence of sample size, correlation and covariance, normal distribution and its parameters), basics of Matla
	basics in optics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can
	Describe imaging processes
	 Depict the physics of sensorics Explain linear and non-linear filtering of signals
	Establish interdisciplinary connections in the subject area and arrange them in their context
	Interpret effects of the most important classes of imaging sensors and displays using mathematical methods and physic
	models.
Skills	Students are able to
	Use highly sophisticated methods and procedures of the subject area Advantage and developed and inches and inches at the subject area.
	Identify problems and develop and implement creative solutions.
	Students can solve simple arithmetical problems relating to the specification and design of image processing and image analys
	systems.
	Students are able to assess different solution approaches in multidimensional decision-making areas.
	17
	Students can undertake a prototypical analysis of processes in Matlab.
Personal Competence	
Social Competence	K.A.
Autonomy	Students can solve image analysis tasks independently using the relevant literature.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and	60 Minutes, Content of Lecture and materials in StudIP
scale	oo minutes, content of Lecture and materials in studir
Assignment for the	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory
Following Curricula	
. Shoming curricula	Electrical Engineering: Specialisation Medical Technology: Electrical Engineering: Specialisation Engineering: Specialisat
	Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory
	Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Software and Sign
	Processing: Elective Compulsory
	International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
	Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

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

Module M0623: Intell	igent Systems in Medicine			
Courses				
Title		Тур	Hrs/wk	СР
Intelligent Systems in Medicine (L0	331)	Lecture	2	3
Intelligent Systems in Medicine (L0	334)	Project Seminar	2	2
Intelligent Systems in Medicine (L0	333)	Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	 principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, Java/C++ and R/Mat advanced programming skills 	ab		
Educational Objectives	After taking part successfully, students have reached t	ne following learning results		
Professional Competence				
Knowledge	The students are able to analyze and solve clinical tre optimization, and planning. They are able to explain m in clinical contexts. The students can compare differer in the context of clinical data and explain challenges and safety requirements.	ethods for classification and their respo at methods for representing medical kn	ective advantage owledge. They c	es and disadvantages an evaluate methods
Skills	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can asses the methods based on actual patient data and evaluate the implemented methods.		ion. They can asses	
Personal Competence				
Social Competence	The students discuss the results of other groups, provide	de helpful feedback and can incoorpora	te feedback into	their work.
Autonomy	The students can reflect their knowledge and docume manner.	nt the results of their work. They can	present the resu	llts in an appropriate
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70)		
Credit points	6			
Course achievement	Compulsory Bonus Form Description Yes 10 % Written elaboration Yes 10 % Presentation	ription		
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	Computer Science: Specialisation II: Intelligence Engine	ering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Medical Technolo	gy: Elective Compulsory		
	Interdisciplinary Mathematics: Specialisation Computat	ional Methods in Biomedical Imaging: 0	Compulsory	
	Mechatronics: Specialisation Intelligent Systems and Re	obotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Er	doprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Techno	logy and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management ar	nd Business Administration: Elective Co	mpulsory	
	Theoretical Mechanical Engineering: Technical Comple	mentary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Bio-	and Medical Technology: Elective Com	pulsory	

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

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

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

Courses						
Title				Тур	Hrs/wk	СР
Industrial Process Automation (L03	44)			Lecture	2	3
Industrial Process Automation (L03	45)			Recitation Section (small)	2	3
Module Responsible	Prof. Alexander Schlae	fer				
Admission Requirements	None					
Recommended Previous	mathematics and optin	nization methods				
Knowledge	principles of automata					
	principles of algorithms	and data structur	es			
	programming skills					
Educational Objectives	After taking part succe	ssfully students h	ave reached the fol	owing learning results		
Professional Competence	Arter taking part succe	ostany, stadents in	ave reactica the for	ownig learning results		
•	The students can evalu	late and assess dis	screte event systen	ns. They can evaluate properties	of processes and	explain methods f
momeage				cess modelling and select an ap		
				ctual problems and give a de		
	-			dents can relate process autor		
	-			I systems' and 'industry 4.0'.		
Skills	The students are able	to develop and m	odel processes and	evaluate them accordingly. This	s involves taking	into account optim
	scheduling, understand	ling algorithmic co	mplexity, and imple	ementation using PLCs.		
Personal Competence	The about out on the first		1			
Social Competence	The students work in to	earns to solve prob	iems.			
				la color		
Autonomy	The students can reflect their knowledge and document the results of their work.					
Workload in Hours	Independent Study Tim	ne 124 Study Time	in Lecture 56			
Workload III Hours		ic 124, Study Tillic				
Credit points						
Course achievement	6	Form	Description	1		
Credit points Course achievement		Form Excercises		1		
· · · · · · · · · · · · · · · · · · ·	6 Compulsory Bonus			1		
Course achievement	6 Compulsory Bonus No 10 %			1		
Course achievement Examination	Compulsory Bonus No 10 % Written exam			1		
Course achievement Examination Examination duration and scale	6 Compulsory Bonus No 10 % Written exam 90 minutes	Excercises	Description	s Engineering: Elective Compuls	ory	
Course achievement Examination Examination duration and scale	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering	Excercises g: Specialisation A	Description - General Bioproces			
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce	Excercises J: Specialisation A ss Engineering: Sp	Description - General Bioproces - ecialisation Chemic	s Engineering: Elective Compuls	Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce	Excercises J: Specialisation A ss Engineering: Sp ss Engineering: Sp	Description - General Bioproces recialisation Chemic recialisation Genera	s Engineering: Elective Compuls al Process Engineering: Elective l Process Engineering: Elective (Compulsory	
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce Chemical and Bioproce Computer Science: Spe	g: Specialisation A ss Engineering: Sp ss Engineering: Sp scialisation II: Intell	Description - General Bioproces pecialisation Chemic pecialisation Genera igence Engineering	s Engineering: Elective Compuls al Process Engineering: Elective l Process Engineering: Elective (Compulsory	
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce Chemical and Bioproce Computer Science: Spe	g: Specialisation A ss Engineering: Sp ss Engineering: Sp scialisation II: Intell Specialisation Con	Description - General Bioproces pecialisation Chemic pecialisation Genera igence Engineering trol and Power Syst	s Engineering: Elective Compuls al Process Engineering: Elective (I Process Engineering: Elective (: Elective Compulsory ems Engineering: Elective Comp	Compulsory	
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce Chemical and Bioproce Computer Science: Spe Electrical Engineering:	g: Specialisation A ss Engineering: Sp ss Engineering: Sp cialisation II: Intell Specialisation Con eering: Core qualif	Description - General Bioproces pecialisation Chemic pecialisation Genera igence Engineering trol and Power Syst ication: Elective Co	s Engineering: Elective Compuls al Process Engineering: Elective I Process Engineering: Elective (: Elective Compulsory ems Engineering: Elective Compulsory	Compulsory	
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce Chemical and Bioproce Computer Science: Spe Electrical Engineering: Aircraft Systems Engin Aircraft Systems Engin	g: Specialisation A ss Engineering: Sp ss Engineering: Sp cialisation II: Intell Specialisation Con eering: Core qualif eering: Specialisat	Description - General Bioproces pecialisation Chemic pecialisation Genera igence Engineering trol and Power Syst ication: Elective Co- ion Cabin Systems:	s Engineering: Elective Compuls al Process Engineering: Elective I Process Engineering: Elective (: Elective Compulsory ems Engineering: Elective Compulsory	Compulsory Compulsory pulsory	
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce Computer Science: Spe Electrical Engineering: Aircraft Systems Engin Aircraft Systems Engin International Managem	g: Specialisation A ss Engineering: Sp ss Engineering: Sp scialisation II: Intell Specialisation Con eering: Core qualif eering: Specialisat ent and Engineerin	Description - General Bioproces decialisation Chemic decialisation Genera digence Engineering trol and Power Syst dication: Elective Col ion Cabin Systems: ng: Specialisation II	s Engineering: Elective Compuls al Process Engineering: Elective I Process Engineering: Elective (: Elective Compulsory ems Engineering: Elective Compulsory Elective Compulsory	Compulsory Compulsory bulsory	ompulsory
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce Chemical and Bioproce Computer Science: Spe Electrical Engineering: Aircraft Systems Engin Aircraft Systems Engin International Managem International Managem	g: Specialisation A ss Engineering: Sp ss Engineering: Sp scialisation II: Intell Specialisation Con eering: Core qualif eering: Specialisat ent and Engineeri ent and Engineeri	Description - General Bioproces decialisation Chemic decialisation Genera digence Engineering trol and Power Syst dication: Elective Collion Cabin Systems: ng: Specialisation II	s Engineering: Elective Compuls al Process Engineering: Elective I Process Engineering: Elective : Elective Compulsory ems Engineering: Elective Compulsory Elective Compulsory . Mechatronics: Elective Compul	Compulsory Compulsory bulsory sory uction: Elective C	ompulsory
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce Computer Science: Spe Electrical Engineering: Aircraft Systems Engin Aircraft Systems Engin International Managem International Managem Mechanical Engineering Mechatronics: Specialis	g: Specialisation A ss Engineering: Sp ss Engineering: Sp cialisation II: Intell Specialisation Con eering: Core qualif eering: Specialisat eent and Engineeri eent and Engineeri g and Managemen sation Intelligent Sp	Description General Bioproces decialisation Chemic decialisation General digence Engineering trol and Power Syst dication: Elective Col dion Cabin Systems: ng: Specialisation II ng: Specialisation II t: Specialisation Me dystems and Robotic	s Engineering: Elective Compuls al Process Engineering: Elective (I Process Engineering: Elective (: Elective Compulsory ems Engineering: Elective Compulsory Elective Compulsory Mechatronics: Elective Compul . Product Development and Proc chatronics: Elective Compulsory s: Elective Compulsory	Compulsory Compulsory Dulsory Sory Suction: Elective C	ompulsory
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce Computer Science: Spe Electrical Engineering: Aircraft Systems Engin Aircraft Systems Engin International Managem International Managem Mechanical Engineering Mechatronics: Specialis Theoretical Mechanical	g: Specialisation A ss Engineering: Sp ss Engineering: Sp scialisation II: Intell Specialisation Con eering: Core qualif eering: Specialisat eent and Engineeri g and Managemen sation Intelligent S; Engineering: Tech	Description General Bioproces decialisation Chemic decialisation General digence Engineering trol and Power Syst dication: Elective Colion Cabin Systems: ng: Specialisation II ng: Specialisation II t: Specialisation Me dystems and Robotic dunical Complementa	s Engineering: Elective Compuls al Process Engineering: Elective (I Process Engineering: Elective (Elective Compulsory ems Engineering: Elective Compulsory Elective Compulsory Mechatronics: Elective Compul Product Development and Procentics: Elective Compulsory s: Elective Compulsory	Compulsory Compulsory Dulsory Sory Suction: Elective C	ompulsory
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce Computer Science: Spe Electrical Engineering: Aircraft Systems Engin Aircraft Systems Engin International Managem International Managem Mechanical Engineering Mechatronics: Specialis Theoretical Mechanical Theoretical Mechanical	g: Specialisation A ss Engineering: Sp ss Engineering: Sp cialisation II: Intell Specialisation Con eering: Core qualif eering: Specialisat ent and Engineering and Managemen sation Intelligent S; Engineering: Tech Engineering: Specialisat specialisation Con eering: Core qualif eering: Specialisat ent and Engineering and Managemen sation Intelligent S; Engineering: Specialisation Engineering:	Description General Bioproces decialisation Chemic decialisation General digence Engineering trol and Power Syst dication: Elective Colion Cabin Systems: ng: Specialisation II ng: Specialisation II t: Specialisation Me dystems and Robotic dicial Complementaticalisation Robotics	s Engineering: Elective Compuls al Process Engineering: Elective (! Process Engineering: Elective (! Elective Compulsory ems Engineering: Elective Compulsory Elective Compulsory Mechatronics: Elective Compul. Product Development and Proc chatronics: Elective Compulsory s: Elective Compulsory ury Course: Elective Compulsory and Computer Science: Elective	Compulsory Compulsory Dulsory Sory Suction: Elective C	ompulsory
Examination Examination duration and scale Assignment for the	6 Compulsory Bonus No 10 % Written exam 90 minutes Bioprocess Engineering Chemical and Bioproce Computer Science: Spe Electrical Engineering: Aircraft Systems Engin Aircraft Systems Engin International Managem International Managem Mechanical Engineering Mechatronics: Specialis Theoretical Mechanical Theoretical Mechanical	excercises g: Specialisation A ss Engineering: Sp ss Engineering: Sp cialisation II: Intell Specialisation Con eering: Core qualif eering: Specialisat ent and Engineering and Managemen sation Intelligent Sp Engineering: Tech Engineering: Specialisation Chem	Description - General Bioproces decialisation Chemic decialisation General digence Engineering trol and Power Systication: Elective Colion Cabin Systems: dig: Specialisation II decialisation II decialisation Melection and Robotic decialisation Robotics decialisation Robotics decialisation Robotics decial Process Engine	s Engineering: Elective Compuls al Process Engineering: Elective (I Process Engineering: Elective (Elective Compulsory ems Engineering: Elective Compulsory Elective Compulsory Mechatronics: Elective Compul Product Development and Proc chatronics: Elective Compulsory s: Elective Compulsory ury Course: Elective Compulsory and Computer Science: Elective ering: Elective Compulsory	Compulsory Compulsory Dulsory Sory Suction: Elective C	ompulsory

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

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

Module M0677: Digita	al Signal Processing and Digital Filter	r'S		
Courses				
Title Digital Signal Processing and Digita Digital Signal Processing and Digita		Typ Lecture Recitation Section (large)	Hrs/wk 3 2	CP 4 2
Module Responsible	Prof. Gerhard Bauch			
Admission Requirements	None			
Recommended Previous Knowledge	Mathematics 1-3 Signals and Systems Fundamentals of signal and system theory as w Fundamentals of spectral transforms (Fourier se	·	iform)	
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Skills Personal Competence Social Competence	The students know and understand basic algorithms of digital signal processing. They are familiar with the spectral transforms of discrete-time signals and are able to describe and analyse signals and systems in time and image domain. They know basic structures of digital filters and can identify and assess important properties including stability. They are aware of the effects caused by quantization of filter coefficients and signals. They are familiar with the basics of adaptive filters. They can perform traditional and parametric methods of spectrum estimation, also taking a limited observation window into account. The students are able to apply methods of digital signal processing to new problems. They can choose and parameterize suitable filter striuctures. In particular, the can design adaptive filters according to the minimum mean squared error (MMSE) criterion and develop an efficient implementation, e.g. based on the LMS or RLS algorithm. Furthermore, the students are able to apply methods of spectrum estimation and to take the effects of a limited observation window into account. The students can jointly solve specific problems. The students are able to acquire relevant information from appropriate literature sources. They can control their level of			
	knowledge during the lecture period by solving tutoria	il problems, software tools, clicker sys	tem.	
	Independent Study Time 110, Study Time in Lecture 7	0		
Credit points				
Course achievement				
Examination				
Examination duration and scale	90 mm			
	Electrical Engineering: Specialisation Control and Pow	er Systems Engineering: Elective Com	pulsory	
_	Computational Science and Engineering: Specialisatio Information and Communication Systems: Specialisati Mechanical Engineering and Management: Specialisat Mechatronics: Specialisation Intelligent Systems and F Microelectronics and Microsystems: Specialisation Cor Theoretical Mechanical Engineering: Technical Comple	n II. Engineering Science: Elective Cor on Communication Systems, Focus Si ion Mechatronics: Elective Compulsor tobotics: Elective Compulsory nmunication and Signal Processing: El	mpulsory gnal Processing: Elo y lective Compulsory	, ,

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

Course L0447: Digital Signal 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

	Module M0832: Adva	nced Topics in Control			
Advanced Tapser in Control (1860) Modula Responsible Port. Netherto Winner Recommended Previous Port. Nether	Courses				
Advanced Tables of Notice (1860) Module Responsible Two first (Noted Notes Notes 2 3 Module Responsible Two first (Noted Notes Notes 2 3 Module Responsible Two first (Noted Notes Notes 2 3 Module Responsible Two first (Noted Notes Notes 2 3 Module Responsible Two first (Noted Notes Notes 2 3 Module Responsible Two first (Notes Notes 2 3 3 Module Responsible Two first (Notes Notes 2 3 3 Module Responsible Two first (Notes Notes N	Title		Tvp	Hrs/wk	СР
Michiels Responsible More Interest Werein Administration Reciments Nove Recommended Previous Recommended Previous Fedurational Objectives Fortissional Competence Anotherise Substitute Fortissional Competence Anotherise Another	Advanced Topics in Control (L0661))		2	3
Admission Requirements Recommended Providus Educational Objectives After taking part successfully, students have needed the following learning results Professional Competence Consolroger - Students can explain the advantages and shortcomings of the classical gain scheduling approach - They can explain the representation of nonlinear systems in the form of quasi-EV systems - They can explain the representation of nonlinear systems in the form of quasi-EV systems - They can explain the expresentation of nonlinear systems in the form of quasi-EV systems - They are familiar with colycopic and LTT representations for LTV systems and some or the basic synthesis techniques associated with each of these model structures - Students can explain how graph theoretic concepts are used to represent the communication topology of multilagent cynemics - They are explain analysis and synthesis conditions for formation control loops involving either LTI or LTV agent models - Students can explain the store space representation of spatially invariant distributed systems that are discretered according to an actuatorysersor array - They can explain the convergence gropered of first gorder consensus protocols - They can explain the convergence gropered of first gorder consensus protocols - They can explain the store space representation of spatially invariant distributed systems that are discretered according to an actuatorysersor array - Students can explain the state space representation of spatially invariant distributed systems and the associated synthesis conditions for distributed controllers - Students are capable of constructing LTV models of nonlinear plants and carry out a mixed-sensitivity design of gain-scheduled controllers for graph of gain-scheduled controllers for spatially interconnected systems, using the Matlab MD isolbex - Students are able to design distributed formation controllers for graphs of agents with either LTI or LTPV dynamics, using Matlab tools provided - Students are able to desig	Advanced Topics in Control (L0662))	Recitation Section (small)	2	3
Recommended Provious Infinity optimal control, mixed-sensitivity design, linear matrix inequalities After taking part successfully, students have reached the following learning results Professional Competence Notwinder Students can explain the advantages and shortcomings of the classical gain scheduling approach They can explain have gridding schridness residents in the form of quasi-IV systems They can explain have gridding schridness can be used to solve analysis and synthesis problems for IVP systems They can explain how gridding schridness can be used to solve analysis and synthesis problems for IVP systems They can explain how gridding schridness can be used to solve analysis and synthesis problems for IVP systems They can explain how graph theoretic concepts are used to represent the basic synthesis techniques associated with each of these model structures Students can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems They can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems They can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems They can explain the state space representation of spatially invariant distributed systems that are discretized according to an actualizational representation of spatially invariant distributed systems and the associated symmetric conditions for distributed controllers State Students are capable of construction IVP models of nonlinear plants and carry out a mixed-ensitivity design of gain-scheduled conditions. They can be this simple polypopic, IVT or general IVP models They are able to the enabled state and the simple polypopic, IVT or general IVP models Students are able to design distributed controllers for spatially internamented systems, using the Matlab MD toolbox Personal Competence Social Competence Social Competence Social Competence Social Competence Social Competence So	Module Responsible	Prof. Herbert Werner			
Educational Objectives After facility part successfully, students have reached the following learning results Professional Competence Annexing **Students can explain the advantages and shortcomings of the classical gain scheduling approach **Hery can explain the progressenation of nonlinear systems in the form of quasi-IPV systems **They can explain the progressenation of nonlinear systems in the form of quasi-IPV systems **They can explain the professional part presentations for IPV systems and professional part part in the progressenation of a nonlinear systems in the form of quasi-IPV systems **They are familiar with polytopic and IPT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures **Students can explain the outperfers of first order consensus protocols **They can explain the convergence properties of first order consensus protocols **They can explain in analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models **Students can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuatromerom army **They can explain fun outline) the extension of the bounded real lemma to such distributed systems and the associated synthesis conditions for distributed cordinales **Students are capable of constructing UP models of nonlinear plants and carry out a mixed-sensitivity design of gain-scheduled controllers; they can do this using polytopic, UT or general LPV models **Students are able to design distributed formation controllers for garups of agents with either LTI or LPV dynamics, using Hatlab tools provided **Students are able to design distributed controllers for spatially interconnected systems, using the Matlah MD 4solbox **Students are able to design distributed controllers for spatially interconnected systems, using the Matlah MD 4solbox **Students are able to design distributed controllers for spatially intercon	Admission Requirements	None			
## After taking part successfully, disclarets have reached the following learning results **Professional Competence** **Allowedge** **Suddents can explain the advantages and shortcomings of the classical quain scheduling approach** **They can explain the advantages and shortcomings of the classical quain scheduling approach** **They can explain the advantages and shortcomings of the classical quain scheduling approach** **They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems on the formulated as LMI conditions** **They are familiar with option/coal and LPT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures **Suddents can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems **They can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems **They can explain the state space representation of spatialty invariant distributed systems that are discretized according to an actuatorsensor array. **Suddents can explain the state space representation of spatialty invariant distributed systems and the associated synthesis conditions for distributed controllers. **Suddents are adule to distributed controllers.** **Suddents are capable of constructing LPV models of nonlinear plants and carry out a mixed sensitivity design of gain-schedulate controllers: they can do this using polycopic. LPT or general LPV models **Suddents are abile to design distributed controllers for groups of agents with either LTI or LPV dynamics, using Mariab trols provided **Suddents are abile to design distributed controllers for spatially interconnected systems, using the Maliab MD-toolbox **Personal Competence** **Suddents are abile to design distributed controllers for spatially interconnected systems, using the Maliab MD-toolbox **Personal Competence** **Suddents are abile to find required informat	Recommended Previous	H-infinity optimal control, mixed-sensitivity design, line	ear matrix inequalities		
Students can explain the advantages and shortcomings of the classical gain scheduling approach **They can explain the representation of nonlinear systems in the form of guast IPV systems **They can explain the advantages and shortcomings of the classical gain scheduling approach **They can explain the advantages and shortcomings of the classical gain scheduling approach **They can explain the did performance conditions for IPV systems can be formulated as LMI conditions **They can explain may indignate the properties of the stress of the systems and some of the basic synthesis techniques associated with each of these model structures **Students can explain the convergence properties of first order consensus protocols **They can explain analysis and synthesis conditions for formation control loops involving either LTI or LTV agent models **Students can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuatorisensor array **They can explain in outline the extension of the bounded real lemma to such distributed systems and the associated synthesis conditions for distributed controllers **Students are capable of constructing LTV models of nonlinear plants and carry out a mixed-sensitivity design of gain-scheduled controllers; they can do this using polytopic. LTF or eneral LTV models **Students are capable to use standard software tools (Mattab robust control toolbox) for these tasks **Students are able to design distributed formation controllers for groups of agents with either LTI or LTV dynamics, using Matlab tools provided **Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-doolloox **Personal Competence* **Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-doolloox **Students are able to design distributed formation controllers for groups of agents with either LTI or LTV dynamics, social assessment for t	Knowledge				
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Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		·		-	
Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory					
			-	20.11pui301 y	
				Compulsory	

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

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

Module M1173: Appli	d Statistics				
Courses					
Title		Тур	Hrs/wk	СР	
Applied Statistics (L1584)		Lecture	2	3	
Applied Statistics (L1586)		Project-/problem-based Learning	2	2	
Applied Statistics (L1585)		Recitation 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 ha	ve reached the following learning results			
Professional Competence					
Knowledge	Students can explain the statistical methods and the conditions of their use.				
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results				
Personal Competence	·	, ,			
•	Team Work, joined presentation of results				
,	,				
Autonomy	To understand and interpret the question	and solve			
Workload in Hours	ndependent Study Time 110, Study Time	in Lecture 70			
Credit points	5				
Course achievement	Compulsory Bonus Form	Description			
	res None Written elaboration	١			
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 Sy	stems and Robotics: Elective Compulsory			
	Biomedical Engineering: Core qualification	n: Compulsory			
	Product Development, Materials and Product	uction: Core qualification: Elective Compulsory			
	•	nical Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Spec	ialisation Bio- and Medical Technology: Elective Compu	ulsory		

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

Course L1586: Applied Statis	stics
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	WiSe
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
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	WiSe
Content	The different statistical tests are applied for the solution of realistic problems using actual data sets and the most common used commercial statistical software package (SPSS).
Literature	Student Solutions Manual for Kleinbaum/Kupper/Muller/Nizam's Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University Lawrence L. Kupper University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University, Published by Duxbury Press, Paperbound © 1998, ISBN/ISSN: 0-534-20913-0

Module M1204: Mode	lling and Optimization in Dynamics			
Courses				
Title Flexible Multibody Systems (L1632)	Typ Lecture	Hrs/wk	CP
Optimization of dynamical systems		Lecture	2	3
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous Knowledge	Mathematics I, II, III Mechanics I, II, III, IV Simulation of dynamical Systems			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
	Students demonstrate basic knowledge and understan multibody systems and methods for optimizing dynamic Students are able			x rigid and flexible
JAMIS	+ to think holistically + to independently, securly and critically analyze and systems + to describe dynamics problems mathematically + to optimize dynamics problems	optimize basic problems of	the dynamics of rigid and	d flexible multibody
Personal Competence Social Competence	Students are able to + solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups and to document to the solve problems in heterogeneous groups are solve problems.	ment the corresponding resu	lts.	
Autonomy	Students are able to + assess their knowledge by means of exercises. + acquaint themselves with the necessary knowledge to	solve research oriented tas	ks.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Core qualification: Elective Aircraft Systems Engineering: Specialisation Aircraft Syst Mechatronics: Specialisation System Design: Elective Co Mechatronics: Specialisation Intelligent Systems and Rot Product Development, Materials and Production: Core qualification: E Theoretical Mechanical Engineering: Core qualification: E Theoretical Mechanical Engineering: Technical Complem	e Compulsory tems: Elective Compulsory mpulsory ootics: Elective Compulsory ualification: Elective Compuls Elective Compulsory		

Course L1632: Flexible Multibody Systems		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Robert Seifried, Dr. Alexander Held	
Language	DE	
Cycle	WiSe	
Content	1. Basics of Multibody Systems 2. Basics of Continuum Mechanics 3. Linear finite element modelles and modell reduction 4. Nonlinear finite element Modelles: absolute nodal coordinate formulation 5. Kinematics of an elastic body 6. Kinetics of an elastic body 7. System assembly	
Literature	Schwertassek, R. und Wallrapp, O.: Dynamik flexibler Mehrkörpersysteme. Braunschweig, Vieweg, 1999. Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014. Shabana, A.A.: Dynamics of Multibody Systems. Cambridge Univ. Press, Cambridge, 2004, 3. Auflage.	

Course L1633: Optimization	of dynamical systems
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	1. Formulation and classification of optimization problems 2. Scalar Optimization 3. Sensitivity Analysis 4. Unconstrained Parameter Optimization 5. Constrained Parameter Optimization 6. Stochastic optimization 7. Multicriteria Optimization 8. Topology Optimization
Literature	Bestle, D.: Analyse und Optimierung von Mehrkörpersystemen. Springer, Berlin, 1994. Nocedal, J., Wright, S.J.: Numerical Optimization. New York: Springer, 2006.

ol Lab B			
	Typ Practical Course Practical Course	Hrs/wk 1 1	CP 1 1
Prof. Herbert Werner			
None			
State space methods LQG control H2 and H-infinity optimal control uncertain plant models and robust control LPV control			
After taking part successfully, students have reached the	e following learning results		
Students can explain the difference between valid	ation of a control lop in simulatio	on and experimental v	ralidation
 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers 			
Students can work in teams to conduct experimen	ats and document the results		
Students can independently carry out simulation s	studies to design and validate co	ntrol loops	
Independent Study Time 32, Study Time in Lecture 28			
2			
None			
Written elaboration			
1			
Electrical Engineering: Specialisation Control and Power 9	Systems Engineering: Elective Co	ompulsory	
	Prof. Herbert Werner None State space methods LQG control H2 and H-infinity optimal control uncertain plant models and robust control LPV control After taking part successfully, students have reached the Students can explain the difference between valid Students are capable of applying basic system dynamic model that can be used for controller syr They are capable of using standard software to controllers They are capable of using standard software tools implementation of H-infinity optimal controllers They are capable of representing model uncertain They are capable of using standard software tools LPV gain-scheduled controllers Students can work in teams to conduct experimer Students can independently carry out simulation is Independent Study Time 32, Study Time in Lecture 28 None Written elaboration Electrical Engineering: Specialisation Control and Power: Mechatronics: Specialisation Intelligent Systems and Rob	Prof. Herbert Werner None State space methods LQG control H2 and H-infinity optimal control uncertain plant models and robust control LPV control After taking part successfully, students have reached the following learning results Students can explain the difference between validation of a control lop in simulation Students are capable of applying basic system identification tools (Matlab System dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Robust Control Toolbox implementation of H-infinity optimal controllers They are capable of using standard software tools (Matlab Robust Control Toolbox implementation of H-infinity optimal controllers They are capable of using standard software tools (Matlab Robust Control Toolbox implementation of H-infinity optimal controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) LPV gain-scheduled controllers Students can work in teams to conduct experiments and document the results Students can independently carry out simulation studies to design and validate controlerence to the study Time 32, Study Time in Lecture 28 None Written elaboration	Typ Hrs/wk Practical Course 1 Prof. Herbert Werner None State space methods LQG control H2 and H-infinity optimal control UPV control After taking part successfully, students have reached the following learning results Students can explain the difference between validation of a control lop in simulation and experimental valuation may be a capable of applying basic system identification tools (Matlab System Identification Todynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and improntrollers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensit implementation of H-infinity optimal controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the LPV gain-scheduled controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the LPV gain-scheduled controllers Students can work in teams to conduct experiments and document the results Students can independently carry out simulation studies to design and validate control loops Independent Study Time 32, Study Time in Lecture 28 None Written elaboration Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory

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

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

Module M1305: Semin	nar Advanced Topics in Control			
Courses				
Title		Тур	Hrs/wk	СР
Advanced Topics in Control (L1803)		Seminar	2	2
Module Responsible				
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 reach	ed the following learning results		
Professional Competence				
Knowledge	Students can explain modern control. Students learn to apply basic control concept	ts for different tasks		
Skills	 Students acquire knowledge about selected aspects of modern control, based on specified literature Students generalize developed results and present them to the participants Students practice to prepare and give a presentation 			
Personal Competence Social Competence	Students are capable of developing solution. They are able to provide appropriate feedba	•	of their own results	
Autonomy	 Students evaluate advantages and drawbacks of different forms of presentation for specific tasks and select the best solution Students familiarize themselves with a scientific field, are able of introduce it and follow presentations of other students, such that a scientific discussion develops 			
Workload in Hours	Independent Study Time 32, Study Time in Lecture	28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and scale	90 min			
Assignment for the	Mechatronics: Specialisation System Design: Electi	ve Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems ar	nd Robotics: Elective Compulsory		

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

Module M1398: Selec	ted Topics in Multibody Dynamics and	Robotics		
Courses				
Title		Тур	Hrs/wk	СР
Formulas and Vehicles - Mathemati	ics and Mechanics in Autonomous Driving (L1981)	Project-/problem-based Learning	2	6
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous	Mechanics IV, Applied Dynamics or Robotics			
Knowledge	Numerical Treatment of Ordinary Differential Equations			
	Control Systems Theory and Design			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	After successful completion of the module students de areas of multibody dynamics and robotics	monstrate deeper knowledge and und	erstanding in	selected application
Skills	Students are able			
	+ to think holistically			
	+ to independently, securly and critically analyze and systems	optimize basic problems of the dynam	ics of rigid ar	nd flexible multiboo
	+ 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 docun	nent the corresponding results and prese	ent them	
Autonomy	Students are able to			
	+ assess their knowledge by means of exercises and pro	jects.		
	+ acquaint themselves with the necessary knowledge to	solve research oriented tasks.		
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28			
Credit points	6	-		
Course achievement	None			
Examination	Presentation			
Examination duration and	тва			
scale				
Assignment for the	Mechatronics: Specialisation Intelligent Systems and Rob	otics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design: Elective Co	mpulsory		
	Theoretical Mechanical Engineering: Technical Complem	entary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualification: E	lective Compulsory		

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

Module M0629: Intell	igent Autonomous Agents and	l Cognitive Rol	ootics		
Carrage					
Courses			_		
Title	Consisting Relation (LODAL)		Тур	Hrs/wk	CP
Intelligent Autonomous Agents and Intelligent Autonomous Agents and	_		Lecture Recitation Section (small)	2	4
Module Responsible			Recitation Section (Sman)		2
Admission Requirements	None				
•					
Knowledge	vectors, matrices, calculas				
Educational Objectives	After taking part successfully, students hav	e reached the followi	ng learning results		
Professional Competence	3		<u> </u>		
	Students can explain the agent abstraction (goals, utilities, environments). They can do can be discussed in terms of decision prolivered scenarios, students can summarize in formalism in static and dynamic settings, settings, with and with complete access to solving (partially observable) Markov decis Students can identify techniques for simul desired states. Students can explain coording equilibria, social choice functions, voting Students can select an appropriate agent students can derive decision trees and appretworks/dynamic Bayesian networks and different sampling techniques for simplified best action or policies for concrete settings states, e.g., Nash equilibria. For multi-agent the results.	escribe the main feat olems and algorithms now Bayesian networl In addition, students to the state of the er sion problems, and the taneous localization nation problems and protocol, and mechal architecture for conc oly basic optimization of apply bayesian read a agent scenarios. Fo s. In multi-agent situa	ures of environments. The n is for solving these problems as can be employed as a known can define decision making avironment. In this context, ney can recall techniques for and mapping, and can explication making in a multi-anism design techniques. For those application for simple queries, r simple and complex decisions students will apply tecisions students will apply tecis.	otion of adversaria For dealing with owledge represent procedures in sir students can desure measuring the valin planning techniques. For simplifications they can a Students can alsion making students for finding the control of th	al agent cooperation uncertainty in real- cation and reasoning mple and sequential cribe techniques for adue of information. Iniques for achieving m of different types and agent application also create Bayesian so name and apply its can compute the g different equilibria.
	Students are able to discuss their solutions Students are able of checking their underst				ns
Workload in Hours	Independent Study Time 124, Study Time in	n Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the	Computer Science: Specialisation II: Intellig	ence Engineering: Ele	ctive Compulsory		
Following Curricula	International Management and Engineering			e Compulsory	
	Mechatronics: Technical Complementary Co	ourse: Elective Compu	ilsory		
	Mechatronics: Specialisation Intelligent Syst	tems and Robotics: E	ective Compulsory		
	Biomedical Engineering: Specialisation Artif	icial Organs and Reg	enerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Impl	lants and Endoprosth	eses: Elective Compulsory		
	Biomedical Engineering: Specialisation Med	ical Technology and (Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Man	-		ompulsory	
	Theoretical Mechanical Engineering: Techni		, ,	Carrante	
	Theoretical Mechanical Engineering: Specia	iisation Robotics and	Computer Science: Elective	Compulsory	

Course L0341: Intelligent Au	tonomous Agents and Cognitive Robotics
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
	Rainer Marrone
Language	
Cycle	
Content	Wise
Content	 Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity, independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations Decision making under uncertainty: Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks Simultaneous Localization and Mapping Planning Game theory (Golden Balls: Split or Share) Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium Social Choice Voting protocols, preferences, paradoxes, Arrow's Theorem, Mechanism Design Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem,
	Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwaite Theorem
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17 Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005 Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridge University Press, 2000
	University Press, 2009

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

Module M1552: Matho	ematics of Neural Networks			
Courses				
Title		Тур	Hrs/wk	СР
Mathematics of Neural Networks (L	.2322)	Lecture	2	3
Mathematics of Neural Networks (L	2323)	Recitation Section (small)	2	3
Module Responsible	Dr. Jens-Peter Zemke			
Admission Requirements	None			
Recommended Previous	Mathematics I-III			
Knowledge	Numerical Mathematics 1/ Numerics			
	3. Programming skills, preferably in Python			
	3 3 1, 3			
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge	Students are able to name, state and classify state-of-t	he-art neural networks and their corr	esponding mathe	ematical basics. They
	can assess the difficulties of different neural networks.			
	Students are able to implement, understand, and, tailor	ed to the field of application, apply no	eural networks.	
Personal Competence				
Social Competence	Students can			
	develop and document joint solutions in small teams;			
	form groups to further develop the ideas and transfer them to other areas of applicability;			
	form a team to develop, build, and advance a software library.			
Autonomy	Students are able to			
	correctly assess the time and effort of self-define	d work:		
	assess whether the supporting theoretical and pr		ndividually or in a	team:
	define test problems for testing and expanding the define test problems for testing and expanding the define test problems.		,	
	assess their individual progess and, if necessary,	to ask questions and seek help.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	25 min			
scale				
Assignment for the	Computer Science: Specialisation III. Mathematics: Elect	tive Compulsory		
Following Curricula	Computational Science and Engineering: Specialisation	III. Mathematics: Elective Compulsory	,	
	Mechatronics: Specialisation Intelligent Systems and Ro	botics: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective	ve Compulsory		
	Technomathematics: Specialisation I. Mathematics: Elec			
	Theoretical Mechanical Engineering: Specialisation Robo	otics and Computer Science: Elective	Compulsory	

Course L2322: Mathematics	of Neural Networks
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	 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/

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

Module M0881: Mathe	ematical Image Processing			
Courses				
Title		Тур	Hrs/wk	СР
Mathematical Image Processing (LC	0991)	Lecture	3	4
Mathematical Image Processing (LC	9992)	Recitation Section (small)	1	2
Module Responsible	Prof. Marko Lindner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Analysis: partial derivatives, gradien			
	Linear Algebra: eigenvalues, least so	juares solution of a linear system		
Educational Objectives	After taking part successfully, students hav	e reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	al and the side of	- was Maria		
	characterize and compare diffusion of the compared of the			
	explain elementary methods of imagexplain methods of image segmenta	· · · · · · · · · · · · · · · · · · ·		
	 explain methods of image segmenta sketch and interrelate basic concept 			
	sketch and interrelate basic concept	3 of functional analysis		
Skills	Students are able to			
	implement and apply elementary methods of image processing			
	explain and apply modern methods of the second	- · · · · · · · · · · · · · · · · · · ·		
		g- pg		
Personal Competence				
Social Competence		heterogeneously composed teams (i.e., teams	from different s	study programs and
	background knowledge) and to explain the	oretical foundations.		
Autonomy				
		neir understanding of complex concepts on their	own. They can sp	ecify open questions
	precisely and know where to get help			
	·	persistence to be able to work for longer period	ds in a goal-orien	ted manner on hard
	problems.			
Workload in Hours	Independent Study Time 124, Study Time in	n Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Bioprocess Engineering: Specialisation A - 0	General Bioprocess Engineering: Elective Compul	sory	
Following Curricula	Computer Science: Specialisation III. Mathe	matics: Elective Compulsory		
		pecialisation III. Mathematics: Elective Compulsor		
	, ,	n Computational Methods in Biomedical Imaging	: Compulsory	
	Mechatronics: Technical Complementary Co			
	Mechatronics: Specialisation System Design			
	Mechatronics: Specialisation Intelligent Sys	• •		
	Technomathematics: Specialisation I. Math			
		ical Complementary Course: Elective Compulsory		
		Ilisation Robotics and Computer Science: Elective	Compulsory	
	Process Engineering: Specialisation Process	Engineering: Elective Compulsory		

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

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

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: Nonli	near Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	Calculus Linear Algebra Engineering Mechanics			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.			
	Students are able to apply existing methods and procesur	res of Nonlinear Dynamics and to	develop novel meth	ods and procedures.
Personal Competence				
,	Students can reach working results also in groups.			
	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.			
	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement	None			
	Written exam			
Examination duration and	2 Hours			
scale				
_	Aircraft Systems Engineering: Core qualification: Elective			
Following Curricula	International Management and Engineering: Specialisation			
	Mechanical Engineering and Management: Specialisation	·	ory	
	Mechatronics: Specialisation System Design: Elective Com Mechatronics: Specialisation Intelligent Systems and Robo	•		
	Biomedical Engineering: Specialisation Artificial Organs and	• •	vo Compulsory	
	Biomedical Engineering: Specialisation Implants and Endo	-		
	Biomedical Engineering: Specialisation Implants and Endo			
	Biomedical Engineering: Specialisation Management and	•		
	Product Development, Materials and Production: Core qua		F 2	
	Theoretical Mechanical Engineering: Technical Compleme	ntary Course: Elective Compulso	ry	
	Theoretical Mechanical Engineering: Core qualification: Ele	ective Compulsory		

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

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				
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge	Embedded systems can be defined as information proce	ssing systems embedded into enclos	ng products. Thi	s course teaches the
	foundations of such systems. In particular, it deals with	an introduction into these systems (r	notions, common	characteristics) and
	their specification languages (models of computation,	hierarchical automata, specification	of distributed sy	stems, task graphs,
	specification of real-time applications, translations betw	een different models).		
	Another part covers the hardware of embedded syste	ms: Sonsors, A/D and D/A converter	s, real-time cap	able communication
	hardware, embedded processors, memories, energy di			
	introduction into real-time operating systems, middlev	are and real-time scheduling. Finally	y, the implemen	tation of embedded
	systems using hardware/software co-design (hardware/	software partitioning, high-level trans	formations of sp	ecifications, energy-
	efficient realizations, compilers for embedded processor	s) is covered.		
Ckilla	After beginn attended the secure attedants about he about		man The student	a aball realize which
SKIIIS	After having attended the course, students shall be at			
	relevant parts of technological competences to use in c able to compare different models of computations and			
	which areas of embedded system design specific risks e		lesigii. Tiley sila	ii be able to juuge iii
Personal Competence	which dreas of embedded system design specific risks e	NSC.		
	Students are able to solve similar problems alone or in a	group and to present the results acco	ordinaly.	
bociai competence	Stadents are able to some similar problems dione of in-	group and to present the results acco		
Autonomy	Students are able to acquire new knowledge from specif	ic literature and to associate this know	wledge with othe	r classes.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement		ption		
	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 seme	ter): Specialisation Computer Science	e: Compulsory	
Following Curricula	Computer Science: Specialisation Computer and Softwar	e Engineering: Elective Compulsory		
	Computer Science: Specialisation I. Computer and Softw	are Engineering: Elective Compulsory		
	Electrical Engineering: Core qualification: Elective Comp	ılsory		
	Engineering Science: Specialisation Mechatronics: Electi			
	Aircraft Systems Engineering: Core qualification: Elective			
	General Engineering Science (English program, 7 semes	•	tive Compulsory	
	Computational Science and Engineering: Core qualificati			
	Mechatronics: Specialisation System Design: Elective Co			
	Mechatronics: Specialisation Intelligent Systems and Rol	ouics: Elective Compulsory		
	Mechatronics: Core qualification: Elective Compulsory	ddod Systoms, Elective Commuter		
	Microelectronics and Microsystems: Specialisation Embe	uueu Systems: Elective Compulsory		

Course L0805: Embedded Sy	stems
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Heiko Falk
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 Systems		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	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	

Module M0805: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)				
Courses				
Title Typ Hrs/				СР
· ·	ves, Noise Protection, Psycho Acoustics) (L0516)	Lecture	2	3
	ves, Noise Protection, Psycho Acoustics) (L0518)	Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and Mecha	nics II (Hydrostatics, Kinematics, Dyn	amics)	
Knowledge	Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge in acoust	ics regarding acoustic waves, noise	protection, and p	sycho acoustics and
	are able to give an overview of the corresponding theore	etical and methodical basis.		
Skills	The students are capable to handle engineering p	roblems in acoustics by theory-ba	ased application	of the demanding
	methodologies and measurement procedures treated within the module.			
Personal Competence				
Social Competence	Students can work in small groups on specific problems	to arrive at joint solutions.		
Autonomy	The students are able to independently solve challeng	ing acquistical problems in the areas	treated within t	he module Possible
, ideanism,	conflicting issues and limitations can be identified and the	-	o created within	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Energy Systems: Core qualification: Elective Compulsory	,		
Following Curricula	Aircraft Systems Engineering: Core qualification: Elective	e Compulsory		
	International Management and Engineering: Specialisation	on II. Aviation Systems: Elective Com	pulsory	
	Mechatronics: Specialisation System Design: Elective Co	•		
	Product Development, Materials and Production: Core qu			
	Technomathematics: Specialisation III. Engineering Scien			
	Theoretical Mechanical Engineering: Technical Complem			
	Theoretical Mechanical Engineering: Specialisation Produ	uct Development and Production: Elec	ctive Compulsory	

Course L0516: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Otto von Estorff	
Language	EN	
Cycle	SoSe 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	

Module M0807: Bound	dary Element Methods			
Courses				
Title		T	Here built	CD
Boundary Element Methods (L0523		Typ Lecture	Hrs/wk 2	CP 3
Boundary Element Methods (L0524		Recitation Section (large)	2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and M	lechanics II (Hydrostatics, Kinematics, Dyn	amics)	
Knowledge	Mathematics I, II, III (in particular differential equat	ions)		
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge rega	rding the derivation of the boundary eler	nent method and	are able to give an
	overview of the theoretical and methodical basis of	the method.		
Skills	The students are capable to handle engineeri	ng problems by formulating suitable b	ooundary elemer	its, assembling the
	corresponding system matrices, and solving the re-	sulting system of equations.		
Personal Competence				
	Students can work in small groups on specific prob	lems to arrive at joint solutions.		
Autonomou	The shudants are able to independently salve abo	Hanning commutational problems and dou	alan awa hawada	m, alamant valitinas
Autonomy	The students are able to independently solve cha Problems can be identified and the results are critic		elop own bounda	ry element routines.
	Troblems can be identified and the results are char	scrutilized.		
Worldood in House	Independent Study Time 124, Study Time in Lectur	2.56		
Workload in Hours Credit points	6	e 30		
Course achievement		Description		
course acmevement	No 20 % Midterm	·		
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Civil Engineering: Specialisation Structural Enginee	ring: Elective Compulsory		
Following Curricula	Civil Engineering: Specialisation Geotechnical Engi	neering: Elective Compulsory		
	Civil Engineering: Specialisation Coastal Engineering			
	Energy Systems: Core qualification: Elective Comp	•		
	Mechanical Engineering and Management: Speciali	·	n: Elective Comp	ulsory
	Mechatronics: Specialisation System Design: Electi			
	Product Development, Materials and Production: Co			
	Technomathematics: Specialisation III. Engineering			
	Theoretical Mechanical Engineering: Technical Com			
	Theoretical Mechanical Engineering: Specialisation	Simulation Technology: Elective Compulso	ory	

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

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

Module M1156: Syste	ms Engineering			
Courses				
Title		Тур	Hrs/wk	СР
Systems Engineering (L1547)		Lecture	3	4
Systems Engineering (L1548)		Recitation Section (large)	1	2
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge	Mathematics			
	Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Control Systems			
	Previous knowledge in:			
	Aircraft Cabin Systems			
Educational Objectives	After taking part successfully, students have reached the f	ollowing learning results		
Professional Competence				
Knowledge	Students are able to:			
	understand systems engineering process models, method	ds and tools for the development o	f complex System	ıs
	describe innovation processes and the need for technological contents.	gy Management		
	explain the aircraft development process and the process.	s of type certification for aircraft		
	explain the system development process, including requi	rements for systems reliability		
	identify environmental conditions and test procedures fo	r airborne Equipment		
	value the methodology of requirements-based engineering	ng (RBE) and model-based requirer	ments engineering	(MBRE)
Skills	Students are able to:			
	plan the process for the development of complex System	S		
	organize the development phases and development Tasks assign required business activities and technical Tasks			
	apply systems engineering methods and tools			
Danas Commetence				
Personal Competence	Chudanta ara ahla ta			
Social Competence	Students are able to: • understand their responsibilities within a development team and integrate themselves with their role in the overall process			
	anderstand their responsibilities within a development te	ani and integrate themselves with	their role in the o	verali process
Autonomy	Students are able to:			
	interact and communicate in a development team which	has distributed tasks		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	, , ,			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 Minutes			
scale				
Assignment for the	Aircraft Systems Engineering: Core qualification: Compulso	ry		
Following Curricula	International Management and Engineering: Specialisation	II. Aviation Systems: Elective Com	pulsory	
	International Management and Engineering: Specialisation	II. Product Development and Produ	uction: Elective Co	mpulsory
	Mechatronics: Specialisation System Design: Elective Comp	•		
	Mechatronics: Specialisation Intelligent Systems and Robot	. ,		
	Product Development, Materials and Production: Specialisa	·	-	
	Product Development, Materials and Production: Specialisa	•	•	
	Product Development, Materials and Production: Specialisa	•	у	
	Theoretical Mechanical Engineering: Technical Complemen			
	Theoretical Mechanical Engineering: Specialisation Aircraft	Systems Engineering: Elective Cor	mpulsory	

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

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

Module M1212: Technical Complementary Course for IMPMEC (according to Subject Specific Regulations)				
Courses				
Title	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			
Autonomy	see selected module according to FSPO			
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			

Module M1223: Selec	ted Topics of Mechatronics (Alterna	tive A: 12 LP)		
Courses				
Title		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	chatronics (L1512)	Lecture	2	3
Fatigue & Damage Tolerance (L03)	10)	Lecture	2	3
Industry 4.0 for engineers (L2012)		Lecture	2	3
Microcontroller Circuits: Implement	tation 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
Process Measurement Engineering	(L1077)	Lecture	2	3
Process Measurement Engineering	(L1083)	Recitation Section (large)	1	1
Feedback 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	d the following learning results		
Professional Competence				
Knowledge	Students are able to express their extended	knowledge and discuss the connection of di	fforent snecia	l fields or application
	areas of mechatronics	knowledge and discuss the conflection of an	петене зресіа	ii ficias of application
	Students are qualified to connect different specified.	ecial fields with each other		
Skills	Students can apply specialized solution strate	egies and new scientific methods in selected	areas	
	Students are able to transfer learned skills to	-		n annroachos
	Students are able to transfer learned skins to	new and unknown problems and can develop	p own solution	парргоаспез
Personal Competence				
Social Competence	None			
Autonomy		1.190.1		
	Students are able to develop their knowledge	and skills by autonomous election of course	S.	
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the	Mechatronics: Specialisation System Design: Elective	e Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and	Robotics: Elective Compulsory		

Course L1592	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	
Lecturer	Prof. Thorsten Schüppstuhl
Language	DE
Cycle	WiSe
Literature	-Project Based Learning -Robot Operating System -Robot structure and description -Motion description -Calibration -Accuracy 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
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
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	120 min
scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der
	deutschen Übersetzung), ISBN 978-3-9818805-0-2.
	ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System
	Life Cycle Processes).

Course L1512: Development	Management for Mechatronics
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 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 morgen 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
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	45 min
scale	
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve
	fatigue strength, environmental influences
Literature	Jaap Schijve, Fatigue of Structures and Materials. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit
	Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989

Course L2012: Industry 4.0 for engineers	
Тур	Lecture
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. Thorsten Schüppstuhl
Language	DE
Cycle	SoSe
Content	
Literature	

Course L0087: Microcontroller Circuits: Implementation in Hardware and Software	
Тур	Seminar
Hrs/wk	2
СР	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
Course L0724: Microsystems	
	Lecture
Hrs/wk	
CP	
	Independent Study Time 92, Study Time in Lecture 28
Examination Form	
Examination duration and	30 min
scale	
Lecturer	
Language	
Cycle	
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, SOI, SCREAM process, LIGA, SUB, 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 sensors, 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 semicond
	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

Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML		
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	

Course L1077: Process Meas	urement Engineering
Тур	Lecture
Hrs/wk	
СР	3
	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	- Dranger management and in ordinaring in the contest of average control engineering
	 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	
СР	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. 	

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Course L1630: Applied Dynamics		
Тур	Lecture	
Hrs/wk	2	
СР	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 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				
Title				
		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 Mechatronics (L1512)		Lecture	2	3
Fatigue & Damage Tolerance (L0310)		Lecture	2	3
Industry 4.0 for engineers (L2012)		Lecture	2	3
Microcontroller Circuits: Implementation in Hardware and	Software (L0087)	Seminar	2	2
Microsystems Technology (L0724)		Lecture	2	4
Model-Based Systems Engineering (MBSE) with SysML/UI	ИL (L1551)	Project-/problem-based Learning	3	3
Process Measurement Engineering (L1077)		Lecture	2	3
Process Measurement Engineering (L1083)		Recitation Section (large)	1	1
Feedback Control in Medical Technology (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 su	ccessfully, students have reached the follow	wing learning results		
Professional Competence				
Knowledge				
Students are	e able to express their extended knowledg	e and discuss the connection of dif	fferent special fi	elds or application
areas of med	chatronics			
Students are	qualified to connect different special field	s with each other		
Skills				
	apply specialized solution strategies and	new scientific methods in selected	areas	
Students are	able to transfer learned skills to new and	unknown problems and can develor	o own solution a	pproaches
		, , , , , , , , , , , , , , , , , , , ,		
Personal Competence				
Social Competence None				
Autonomy				
Students are	able to develop their knowledge and skills	by autonomous election of courses	S.	
Workload in Hours Depends on choice	of courses			
Credit points 6				
Assignment for the Mechatronics: Spec	ialisation System Design: Elective Compul	sory		
Following Curricula Mechatronics: Spec	ialisation Intelligent Systems and Robotics	: Elective Compulsory		

Course L1592: 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		
Lecturer	Prof. Thorsten Schüppstuhl	
Language	DE	
Cycle	WiSe	
Literature	-Project Based Learning -Robot Operating System -Robot structure and description -Motion description -Calibration -Accuracy 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
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 Training Course SE-ZERT		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	120 min	
scale		
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content		
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der deutschen Übersetzung), ISBN 978-3-9818805-0-2. ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System	
	Life Cycle Processes).	

Course L1512: Development	Management for Mechatronics
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 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 morgen 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	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	45 min	
scale		
Lecturer	Dr. Martin Flamm	
Language	EN	
Cycle	WiSe	
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve	
	fatigue strength, environmental influences	
Literature	Jaap Schijve, Fatigue of Structures and Materials. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit	
	Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989	

Course L2012: Industry 4.0 for engineers	
Тур	Lecture
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. Thorsten Schüppstuhl
Language	DE
Cycle	SoSe
Content	
Literature	

Course L0087: Microcontroller Circuits: Implementation in Hardware and Software		
Тур	Seminar	
Hrs/wk	2	
СР	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
	Lecture
Hrs/wk	
CP	
	Independent Study Time 92, Study Time in Lecture 28
Examination Form	
Examination duration and	
scale	
	Prof. Hoc Khiem Trieu
Language	EN
Cycle	
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, SOI, SCREAM process, LIGA, SUB, 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: bellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, Clark electrode,
	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

Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML		
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	

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:	
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	
СР	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	1. Modelling of Multibody Systems 2. Basics from kinematics and kinetics 3. Constraints 4. Multibody systems in minimal coordinates 5. State space, linearization and modal analysis 6. Multibody systems with kinematic constraints 7. Multibody systems as DAE 8. Non-holonomic multibody systems 9. 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.	

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Module Responsible Admission Requirements Recommended Previous Knowledge Educational Objectives Frofessional Competence Knowledge Educational Objectives Frofessional Competence Knowledge Cyber-Physical Systems (CPS) are tightly integrated with their surrounding environment, via sensors, A/D and D/A converters, actors. Due to their particular application areas, highly specialized sensors, processors and actors are common. Accordingly, the is a large variety of different specification approaches for CPS - 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. Iab introduces into the area (basic notions, characteristical properties) and their specification techniques (models of computal hierarchical automata, data flow models, petri nets, imperative approaches). Since CPS frequently perform control tasks, the le experiments will base on simple control applications. The experiments will use state-of-the-art industrial specification to (MATLAB/Simulink, LabVIEW, NXC) in order to model cyber-physical models that interact with the environment via sensors actors. Skills After successful attendance of the lab, students are able to develop simple CPS. They understand the interdependencies between the computer of the	Courses	
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Workload in Hours Independent Study Time 124, Study Time in Lecture 56 Credit points 6 Course achievement None Examination Written elaboration	Social Competence	Students are able to solve similar problems alone or in a group and to present the results accordingly.
Credit points 6 Course achievement None Examination Written elaboration	Autonomy	Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.
Course achievement None Examination Written elaboration	Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Examination Written elaboration	Credit points	6
	Course achievement	None
Examination duration and Execution and documentation of all lab experiments	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	Following Curricula	
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 Memgent Systems and Nobotics. Elective Compulsory		
Mechatronics: Technical Complementary Course: Elective Compulsory		

Course L1740: Lab Cyber-Phy	ysical Systems
Тур	Project-/problem-based Learning
Hrs/wk	4
СР	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	rol Lab C			
riodalic Filzboor Contr				
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)	I	Practical Course	1	1
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	State space methods			
Knowledge	LQG control			
	H2 and H-infinity optimal control			
	uncertain plant models and robust control			
	LPV control			
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	Students can explain the difference between	en validation of a control lop in simulation	and experimental v	validation
Skills Personal Competence Social Competence	 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers 			
Autonomy	Students can independently carry out simu	alation studies to design and validate con	trol loops	
Workload in Hours	Independent Study Time 48, Study Time in Lectur	re 42		
Credit points				
Course achievement				
Examination	Written elaboration			
Examination duration and	1			
scale				
Assignment for the	Electrical Engineering: Specialisation Control and	Power Systems Engineering: Elective Cor	mpulsory	
Following Curricula	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elec	tive Compulsory		
	Theoretical Mechanical Engineering: Core qualific	ation: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Co	mplementary Course: Elective Compulso	ry	
	l			

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

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

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

Module M1281: Adva	nced Topics in Vibration			
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	ne following learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts of A	dvanced Vibrations and to develop and resea	arch new terms	and concepts.
Skills	Students are able to apply existing methods and procesures	of Advanced Vibrations and to develop novel	methods and p	procedures.
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks individu	ally and 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 C	ompulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Ro	botics: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Electi	ve Compulsory		
	Theoretical Mechanical Engineering: Technical Compler	nentary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Prod	uct Development and Production: Elective	e Compulsory	

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

Module M0835: Huma	noid Robotics			
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			
	Control theory and design			
	control and design			
Educational Objectives	After taking part successfully, students have re-	ached the following learning results		
Professional Competence				
Knowledge	Students can explain humanoid robots.			
	Students learn to apply basic control con	cepts for different tasks in humanoid rol	botics.	
Skills				
SKIIIS	Students acquire knowledge about select	ted aspects of humanoid robotics, based	I on specified literature	
	 Students generalize developed results ar 	nd present them to the participants		
	Students practice to prepare and give a property in the students practice to prepare and give a property in the students practice.	presentation		
Personal Competence				
Social Competence				
	Students are capable of developing solut The company of the properties of the capable for the capable fo			
	They are able to provide appropriate feet	aback and handle constructive criticism	of their own results	
Autonomy	Students evaluate advantages and dra	whacks of different forms of procental	tion for specific tasks	and coloct the best
	solution	wbacks of different forms of presental	don for specific tasks	and select the best
	Students familiarize themselves with a :	scientific field, are able of introduce it	and follow presentation	s of other students,
	such that a scientific discussion develops			
Waldard In Harris	Index and act Charle Time 22. Shorts Time in Last	20		
Workload in Hours Credit points	Independent Study Time 32, Study Time in Lect	ure 28		
Course achievement				
Examination				
Examination duration and				
scale				
Assignment for the	Mechatronics: Specialisation Intelligent Systems	s and Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design: Ele	ective Compulsory		
	Biomedical Engineering: Specialisation Artificial			
	Biomedical Engineering: Specialisation Implants			
	Biomedical Engineering: Specialisation Medical			
	Biomedical Engineering: Specialisation Manage			
	Theoretical Mechanical Engineering: Technical (-	
	Theoretical Mechanical Engineering: Specialisat	ion roporics and computer science; Fie	ctive compulsory	

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

Module M0838: Linea	r and Nonlinear System Ider	ntifikation		
Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Identi	fication (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	 Classical control (frequency responsible) State space methods Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic 	omposition		
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy	nonlinear model structures They can explain how multilayer p They can explain how an approxin They can explain the idea of subsp Students are capable of applying models for dynamic systems They are capable of implementing They are capable of applying subs They can do the above using stand	framework of the prediction error method a erceptron networks are used to model nonline nate predictive control scheme can be based of pace identification and its relation to Kalman rule the prediction error method to the experima a nonlinear predictive control scheme based pace algorithms to the experimental identification dard software tools (including the Matlab System provided (lecture notes, literation).	ear dynamics on neural network mode ealisation theory nental identification of on a neural network mo ation of linear models for em Identification Toolbo	linear and nonline del r dynamic systems x)
	solve given problems.			
	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale	Floring Fording Consider Con-	that and Barres Contains Francisco Florida	Commission	
Assignment for the Following Curricula	Mechatronics: Specialisation Intelligent S Mechatronics: Specialisation System Des Biomedical Engineering: Specialisation A Biomedical Engineering: Specialisation In	rtificial Organs and Regenerative Medicine: Ele nplants and Endoprostheses: Elective Compuls edical Technology and Control Theory: Compu	ective Compulsory sory ulsory	

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

Module M0939: Contr	ol Lab A			
Courses				
Title Control Lab I (L1093) Control Lab II (L1291) Control Lab III (L1665) Control Lab IV (L1666)		Typ Practical Course Practical Course Practical Course Practical Course	Hrs/wk 1 1 1	CP 1 1 1
Module Responsible	Prof. Herbert Werner			
Admission Requirements Recommended Previous	None • State space methods			
Knowledge	LQG control H2 and H-infinity optimal control uncertain plant models and robust control LPV control			
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence Knowledge				ralidation
Skills	 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQC controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers 			lementation of LQG ivity design and the
Personal Competence Social Competence	Students can work in teams to conduct exper	iments and document the results		
Autonomy	Students can independently carry out simular	tion studies to design and validate con	trol loops	
Workload in Hours	Independent Study Time 64, Study Time in Lecture	56		
Credit points	4			
Course achievement	None			
Examination duration and scale				
	Electrical Engineering: Specialisation Control and Po	ower Systems Engineering: Elective Co	mpulsory	
-			i)	
	Mechatronics: Specialisation Intelligent Systems and			
	Theoretical Mechanical Engineering: Technical Com		ry	
	Theoretical Mechanical Engineering: Specialisation I	Robotics and Computer Science: Electi	ve Compulsory	

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

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

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

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

Module M0924: Softw	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 (small)	3	3
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous Knowledge	Good knowledge and experience in programming language C			
Educational Objectives	After taking part successfully, students have reach	ned the following learning results		
Professional Competence				
	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 concrete microcontroller. The participants explain requirements of real time systems. They know at least three scheduling algorithms for real time operating systems including their pros and cons. Students build interrupt-based programs for a concrete microcontroller. They build and use a preemptive scheduler. They use peripheral components (timer, ADC, EEPROM) to realize complex tasks for embedded systems. To interface with external components they utilize serial protocols.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 110, Study Time in Lectu	re 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Mechatronics: Technical Complementary Course: E	Elective Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems a	nd Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elect	ive Compulsory		
	Microelectronics and Microsystems: Specialisation	Embedded Systems: Elective Compulso	ry	

Course L1069: Software for I			
Тур	ecture		
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 Embdedded Systems		
Тур	Recitation Section (small)	
Hrs/wk	3	
СР	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	

Module M1248: Comp	ilers for Embedded Systems			
Courses				
Title		Тур	Hrs/wk	СР
Compilers for Embedded Systems (L1692)	Lecture	3	4
Compilers for Embedded Systems (L1693)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Heiko Falk			
Admission Requirements	None			
Recommended Previous	Module "Embedded Systems"			
Knowledge	C/C++ Programming skills			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	The relevance of embedded systems increases from year to year. Within such systems, the amount of software to be executed embedded processors grows continuously due to its lower costs and higher flexibility. Because of the particular application of embedded systems, highly optimized and application-specific processors are deployed. Such highly specialized protein impose high demands on compilers which have to generate code of highest quality. After the successful attendance of this the students are able • to illustrate the structure and organization of such compilers, • to distinguish and explain intermediate representations of various abstraction levels, and			
	 to assess optimizations and their underlying problems in all compiler phases. The high demands on compilers for embedded systems make effective code optimizations mandatory. The students learn in particular, 			
	which kinds of optimizations are applicable at the how the translation from source code to assembly which kinds of optimizations are applicable at the how register allocation is performed, and how memory hierarchies can be exploited effective. Since compilers for embedded systems often have to optionergy dissipation, code size), the students learn to evaluate.	code is performed, assembly code level, ely. imize for multiple objectives (e.g., aver		
Skills	After successful completion of the course, students shall be enabled to assess which kind of code optimization shassembly code) within a compiler.	ould be applied most effectively at whic	h abstraction	level (e.g., source
	While attending the labs, the students will learn to imple	nent a fully functional compiler includin	g optimization	15.
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 specifi	c literature and to associate this knowle	dge with othe	r classes.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Computer Science: Specialisation I. Computer and Softwa	re Engineering: Elective Compulsory		·
Following Curricula	Electrical Engineering: Specialisation Information and Co	mmunication Systems: Elective Compuls	sory	
	Aircraft Systems Engineering: Core qualification: Elective	Compulsory		
	Mechatronics: Specialisation Intelligent Systems and Rob	otics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective Cor	npulsory		
	Mechatronics: Technical Complementary Course: Elective	Compulsory		
	Theoretical Mechanical Engineering: Technical Compleme			
	Theoretical Mechanical Engineering: Specialisation Robot	ics and Computer Science: Elective Com	pulsory	

Course L1692: Compilers for Embedded Systems			
Тур	Lecture		
Hrs/wk	3		
СР	4		
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	Prof. Heiko Falk		
Language	DE/EN		
Cycle	SoSe		
Content	 Introduction and Motivation Compilers for Embedded Systems - Requirements and Dependencies Internal Structure of Compilers Pre-Pass Optimizations HIR Optimizations and Transformations Code Generation LIR Optimizations and Transformations Register Allocation WCET-Aware Compilation Outlook 		
Literature	 Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 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	ourse L1693: Compilers for Embedded Systems		
Тур	Project-/problem-based Learning		
Hrs/wk	1		
СР	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Heiko Falk		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0840: Optin	nal and Robust Control			
Courses				
Title		Тур	Hrs/wk	СР
Optimal and Robust Control (L0658	s)	Lecture	2	3
Optimal and Robust Control (L0659	0)	Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	• Classical central (frequency response root leggs)			
Knowledge	Classical control (frequency response, root locus) State space methods			
	Linear algebra, singular value decomposition			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				
Knowledge	Students can explain the significance of the matri	x Riccati equation for the solution of	I O problems	
	They can explain the duality between optimal star			
	They can explain how the H2 and H-infinity norms			traints.
	They can explain how an LQG design problem car	be formulated as special case of an	H2 design proble	m.
	They can explain how model uncertainty can be in	represented in a way that lends itself	to robust control	ler design
	They can explain how - based on the small gain	theorem - a robust controller can gu	arantee stability	and performance fo
	an uncertain plant.			
	They understand how analysis and synthesis cond	litions on feedback loops can be repr	esented as linear	matrix inequalities.
Skills				
Skills	 Students are capable of designing and tuning LQC 	controllers for multivariable plant m	iodels.	
	 They are capable of representing a H2 or H-infinit 	y design problem in the form of a ge	neralized plant, a	nd of using standar
	software tools for solving it.			
	They are capable of translating time and frequent		loops into consti	raints on closed-loo
	sensitivity functions, and of carrying out a mixed-			
	They are capable of constructing an LFT uncertainty	ainty model for an uncertain system	i, and of designir	ig a mixed-objectiv
	robust controller.			
	 They are capable of formulating analysis and syn LMI-solvers for solving them. 	thesis conditions as linear matrix ine	equalities (LMI), a	nd of using standard
	They can carry out all of the above using standard	software tools (Matlah rohust contro	al taalbax)	
	They can carry out an or the above using standard	a software tools (Matlab Tobast Contin	or toolbox).	
Personal Competence				
Social Competence	Students can work in small groups on specific problems	to arrive at joint solutions.		
Autonomy				
	solve given problems.	solve given problems.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Control and Power	Systems Engineering: Elective Comp	ulsory	
Following Curricula	1		•	
	Aircraft Systems Engineering: Core qualification: Elective	e Compulsory		
	Mechatronics: Specialisation Intelligent Systems and Rol	ootics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective Co	mpulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Implants and Enc	loprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	gy and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management and	Business Administration: Elective Co	ompulsory	
	Product Development, Materials and Production: Special	isation Product Development: Electiv	e Compulsory	
	Product Development, Materials and Production: Specialisation Production: Elective Compulsory			
	Product Development, Materials and Production: Special	·	У	
	Theoretical Mechanical Engineering: Technical Complem			
	Theoretical Mechanical Engineering: Core qualification:	elective Compulsory		

Course L0658: Optimal and F	lobust 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	ourse L0659: Optimal and Robust Control				
Тур	citation Section (small)				
Hrs/wk	2				
СР	3				
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28				
Lecturer	of. Herbert Werner				
Language	EN				
Cycle	SoSe				
Content	See interlocking course				
Literature	See interlocking course				

Module M1400: Desig	ın of Dependable	e Systems							
Courses									
Title				Тур	Hrs/wk	СР			
Designing Dependable Systems (L2000)				Lecture	2	3			
Designing Dependable Systems (L2	2001)			Recitation Section (small)	2	3			
Module Responsible	Prof. Görschwin Fey								
Admission Requirements	None								
Recommended Previous	Basic knowledge about	data structures and alg	gorithms						
Knowledge									
Educational Objectives	After taking part succes	ssfully, students have r	eached the following	ng learning results					
Professional Competence									
Knowledge	In the following "depen-	dable" summarizes the	concepts Reliabilit	ty, Availability, Maintainabili	ty, Safety and Secu	urity.			
	Knowledge about appro	oaches for designing de	pendable systems	, e.g.,					
	Structural solution	ons like modular redund	dancy						
		tions like handling byza	•	ckpointing					
	Knowledge about meth	ada far tha analysis of	dan an dahla ayatan						
	Knowledge about meth	ous for the analysis of t	dependable system	15					
Skills	Ahility to implement de	nendahle systems usin	a the above appro-	aches					
Skins	Ability to implement de	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								
	discuss relevant	tonics in class and							
	present their solu	•							
	present their son	ations orany.							
Autonomy	Using accompanying n	naterial students indep	pendently learn in	-depth relations between c	oncepts explained	I in the lecture and			
	additional solution strat								
Workload in Hours		e 124, Study Time in Lo	ecture 56						
Credit points		F	B						
Course achievement		Form Subject theoretical	Description	einer Aufgabe ist Zuslassun	insvoralissetziing f	für die Prüfung Die			
		practical work	_	in Vorlesung und Übung de	-	di die Fraiding. Die			
Examination		F		gg doi					
Examination duration and									
scale									
Assignment for the	Computer Science: Spe	cialisation I. Computer	and Software Engi	neering: Elective Compulsor	У				
Following Curricula		•	_	ter Science: Elective Compu	-				
	Information and Comm	unication Systems: Spe	cialisation Secure	and Dependable IT Systems	: Elective Compuls	ory			
	Mechatronics: Specialisation System Design: Elective Compulsory								
	Microelectronics and Mi	icrosystems: Specialisa	ficroelectronics and Microsystems: Specialisation Embedded Systems: Elective Compulsory						

Course L2000: Designing Dep	pendable Systems
Тур	Lecture
Hrs/wk	2
СР	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
	Maintainability
	Safety Sawith
	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				
	Recitation Section (small)			
Hrs/wk				
СР	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Görschwin Fey			
Language	DE/EN			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Courses							
Title	Compatibility (11000)	Тур	Hrs/wk	CP			
	nas, and Electromagnetic Compatibility (L1669)	Lecture Recitation Section (small)	3	4			
	Prof. Christian Schuster						
Admission Requirements	None						
Recommended Previous	Basic principles of physics and electrical engineering						
Knowledge							
Educational Objectives	After taking part successfully, students have reached th	e following learning results					
Professional Competence							
Knowledge		s, and methods for the design of wa	veguides and an	tennas as well as			
	Electromagnetic Compatibility. Specific topics are:						
	- Fundamental properties and phenomena of electrical c	ircuits					
	- Steady-state sinusoidal analysis of electrical circuits						
	- Fundamental properties and phenomena of electromag	netic 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 waveguides and their properti	es					
	- Radiation and basic antenna parameters						
	- Most important types of antennas and their properties						
	- Numerical techniques and CAD tools for waveguide and	d antenna design					
	- Fundamentals of Electromagnetic Compatibility						
	- Coupling mechanisms and countermeasures						
	- Shielding, grounding, filtering						
	- Standards and regulations						
	- EMC measurement techniques						
Skille	Students know how to apply various methods and models for characterization and choice of waveguides and antennas. They are						
Skills	able to assess and qualify their basic electromagne						
	Electromagnetic Compatibility to the development of ele		its and strategi	es from the field			
	Liectromagnetic compatibility to the development of ele	ctrical components and systems.					
Personal Competence							
Social Competence	Students are able to work together on subject related	tasks in small groups. They are able	to present their	results effectively			
	English (e.g. during small group exercises).						
Autonomy	Chudanta are canable to gether information from sub-	ast valated avafactional sublication		t information to th			
Autonomy	, , ,						
	context of the lecture. They are able to make a connection other lectures (e.g. theory of electromagnetic fields, further lectures)						
		idamentais of electrical engineering	physics). They o	an discuss technic			
Worldood in House	problems and physical effects in English.						
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70						
Credit points	6						
Course achievement							
Examination	Oral exam						
Examination duration and	45 min						
scale							
Assignment for the	General Engineering Science (German program, 7 seme	ster): Specialisation Electrical Enginee	ering: Elective Co	mpulsory			
Following Curricula	Electrical Engineering: Core qualification: Elective Comp	ulsory					
	Aircraft Systems Engineering: Core qualification: Elective	e Compulsory					
	Mechatronics: Specialisation System Design: Elective Compulsory						

Course L1669: Introduction t	o Waveguides, Antennas, and Electromagnetic Compatibility
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	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 - Fundamental properties and phenomena 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 waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
	- 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)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility				
Тур	Recitation Section (small)			
Hrs/wk	2			
СР	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			

Module M0627: Mach	ine Learning and Data Mining			
Courses				
Title Machine Learning and Data Mining Machine Learning and Data Mining		Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 4 2
Module Responsible				
Admission Requirements	None			
Recommended Previous	None			
Knowledge	Calculus Stochastics			
Educational Objectives	After taking part successfully, students have reache	ed the following learning results		
Professional Competence				
	Students can explain the difference between instance-based and model-based learning approaches, and they can enumerate basic machine learning technique for each of the two basic approaches, either on the basis of static data, or on the basis of incrementally incoming data. For dealing with uncertainty, students can describe suitable representation formalisms, and they explain how axioms, features, parameters, or structures used in these formalisms can be learned automatically with different algorithms. Students are also able to sketch different clustering techniques. They depict how the performance of learned classifiers can be improved by ensemble learning, and they can summarize how this influences computational learning theory. Algorithms for reinforcement learning can also be explained by students. Student derive decision trees and, in turn, propositional rule sets from simple and static data tables and are able to name and explain basic optimization techniques. They present and apply the basic idea of first-order inductive leaning. Students apply the BME, MAP, ML, and EM algorithms for learning parameters of Bayesian networks and compare the different algorithms. They also know how to carry out Gaussian mixture learning. They can contrast kNN classifiers, neural networks, and support vector machines, and name their basic application areas and algorithmic properties. Students can describe basic clustering techniques and explain the basic components of those techniques. Students compare related machine learning techniques, e.g., k-means clustering and nearest neighbor classification. They can distinguish various ensemble learning techniques and compare the different goals of those techniques.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	, , ,	e 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the				
Following Curricula	International Management and Engineering: Specia	**	e Compulsory	
	Mechatronics: Technical Complementary Course: El	• •		
	Mechatronics: Specialisation System Design: Electiv			
	Mechatronics: Specialisation Intelligent Systems an	• •		
	Theoretical Mechanical Engineering: Technical Com		Compulee	
	Theoretical Mechanical Engineering: Specialisation	KUDULICS and Computer Science: Elective (Loinpuisory	

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

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

Module M0565: Mech	atronic Systems					
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)				Project-/problem-based Learning	2	2
Module Responsible	NN					
Admission Requirements	None					
Recommended Previous	Fundamentals of mechanic	s, electromechanics	and control theor	у		
Knowledge						
Educational Objectives	After taking part successfu	lly, students have re	ached the followir	ng learning results		
Professional Competence						
Knowledge	Students are able to desc	ribe methods and ca	Iculations to des	ign, model, simulate and optim	ize mechatror	nic systems and can
	repeat methods to verify a	nd validate models.				
Skills	Students are able to plan	and execute mecha	tronic experimen	nts. Students are able to model	mechatronic	systems and derive
	simulations and optimization	ons.				
Personal Competence						
Social Competence	Students are able to work	goal-oriented in sma	II mixed groups, I	learning and broadening teamwo	ork abilities ar	nd define task within
	the team.					
Autonomy	Students are able to solve	individually exercises	s related to this le	ecture with instructional direction	٦.	
	Students are able to plan,	execute and summar	ize a mechatronio	c experiment.		
	Independent Study Time 1	10, Study Time in Le	cture 70			
Credit points						
Course achievement	Compulsory Bonus Form		Description			
			and			
		ctical work				
Examination						
Examination duration and	90 min					
scale						
-	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					
Following Curricula	Mechatronics: Specialisation System Design: Elective Compulsory					

Course L0174: Electro- and C	Course L0174: Electro- and Contromechanics	
Тур	Lecture	
Hrs/wk	2	
СР	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 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
СР	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® RTW
Literature	- Abhängig vom Versuchsaufbau
	- Depends on the experiment

Module M1143: Applie	ed Design Methodology in Mechatronics			
Courses				
Title		Тур	Hrs/wk	СР
Applied Design Methodology in Med		Lecture	2	2
Applied Design Methodology in Med	chatronics (L1524)	Project-/problem-based Learning	3	4
Module Responsible	Prof. Thorsten Kern			
Admission Requirements	None			
Recommended Previous	Basics of mechanical design, electrical design or computer-sci	ences		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follo	wing learning results		
Professional Competence				
Knowledge	Science-based working on interdisciplinary product design cor	sidering targeted application of sp	ecific product d	esign techniques
Skills	Creative handling of processes used for scientific preparation	and formulation of complex produc	ct design proble	ems / Application of
	various product design techniques following theoretical aspec		, , , , ,	., ,,,
Personal Competence				
Social Competence	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application of			
	common, creative methodologies.			
	Students are enabled to optimize the design and developmen	t process according to the target a	nd topic of the o	lesign
	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and	30 min Presentation for a group design-work			
scale				
Assignment for the	International Management and Engineering: Specialisation II. I	Product Development and Production	on: Elective Con	npulsory
Following Curricula	International Management and Engineering: Specialisation II. I	Mechatronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation Prod	uct Development and Production: I	Elective Compul	sory
	Mechatronics: Specialisation System Design: Elective Compuls	sory		
	Biomedical Engineering: Specialisation Artificial Organs and Re	-	npulsory	
	Biomedical Engineering: Specialisation Implants and Endopros			
	Biomedical Engineering: Specialisation Medical Technology an	·	-	
	Biomedical Engineering: Specialisation Management and Busi		-	
	Theoretical Mechanical Engineering: Specialisation Product De	•	e Compulsory	
	Theoretical Mechanical Engineering: Technical Complementar	y Course: Elective Compulsory		

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

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

Module M1616: Flight	Control Law Design and Application			
Courses				
Title Flight Control Law Design and Appl Flight Control Law Design and Appl		Typ Lecture Project-/problem-based Learning	Hrs/wk 2 2	CP 4 2
Module Responsible		Project-/problem-based Learning	2	2
Admission Requirements				
Recommended Previous	Basic Knowledge in:			
Knowledge	* Mathematics (Linear Algebra and ordinary differential e	equations)		
	* Control Systems (Transfer functions and state space re	presentation)		
	* Mechanics (Rigid-body kinetics)			
	* Flight Mechanics			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				
Knowledge	Students are able to:			
	* describe and understand flight dynamics models for co	ntrol tasks		
	* assess handling qualities and understand the need for	augmentation through control systems		
	* identify fundamental limitations on performance of con	trol laws		
Skills	Students are able to:			
	* design model-based control laws for stability augmenta	ition		
	* 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 req	uirements and results		
Autonomy	Students are able to:			
	* reflect on the contents of lectures and extend their kno	wledge through literature research		
	* solve control design tasks with software tools			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
	Aircraft Systems Engineering: Core qualification: Elective			
Following Curricula	Mechatronics: Specialisation System Design: Elective Co			
	Mechatronics: Technical Complementary Course: Elective	e Compulsory		

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	
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
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0603: Nonli	near Structural Analysis			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Structural Analysis (L027	7)	Lecture	3	4
Nonlinear Structural Analysis (L027	9)	Recitation Section (small)	1	2
Module Responsible	Prof. Alexander Düster			
Admission Requirements	None			
Recommended Previous	Knowledge of partial differential equations is reco	mmended.		
Knowledge				
Educational Objectives	After taking part successfully, students have reach	ned the following learning results		
Professional Competence				
•	Students are able to			
	+ give an overview of the different nonlinear pher	nomena in structural mechanics.		
	+ explain the mechanical background of nonlinea			
	+ to specify problems of nonlinear structural ana	•	nd to explain the	eir mathematical and
	mechanical background.	, , , , , , , , , , , , , , , , , , , ,		
	3			
Skills	Students are able to			
	+ model nonlinear structural problems.			
	+ select for a given nonlinear structural problem a	a suitable computational procedure.		
	+ apply finite element procedures for nonlinear st	ructural analysis.		
	+ critically verify and judge results of nonlinear fir	nite elements.		
	+ to transfer their knowledge of nonlinear solution	procedures to new problems.		
Personal Competence				
•	Students are able to			
30ciai competence	+ solve problems in heterogeneous groups and to	document the corresponding results		
	+ share new knowledge with group members.	document the corresponding results.		
	+ share new knowledge with group members.			
Autonomy	Students are able to			
	+ acquire independently knowledge to solve comp	olex problems.		
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ire 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Civil Engineering: Specialisation Structural Engine	ering: Elective Compulsory		
Following Curricula	International Management and Engineering: Speci		ulsory	
-	Materials Science: Specialisation Modeling: Electiv	e Compulsory	-	
	Mechatronics: Specialisation System Design: Elect	ive Compulsory		
	Product Development, Materials and Production: C			
	Naval Architecture and Ocean Engineering: Core of			
	Ship and Offshore Technology: Core qualification:			
	Theoretical Mechanical Engineering: Technical Co			
	Theoretical Mechanical Engineering: Specialisation	n Simulation Technology: Elective Compulso	ry	

Course L0277: Nonlinear Structural Analysis		
Тур	Lecture	
Hrs/wk	3	
СР	4	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Alexander Düster	
Language	DE/EN	
Cycle	WiSe	
Content	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 Structural Analysis	
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Alexander Düster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0746: Micro	system Enginee	ring				
Courses						
Title				Тур	Hrs/wk	СР
Microsystem Engineering (L0680)				Lecture	2	4
Microsystem Engineering (L0682)				Project-/problem-based Learning	2	2
Module Responsible	Dr. rer. nat. Thomas K	usserow				
Admission Requirements	None					
Recommended Previous	Basic courses in physic	s, mathematics a	and electric engineering			
Knowledge						
Educational Objectives	After taking part succe	essfully, students	have reached the following	ng learning results		
Professional Competence						
Knowledge	The students know at	out the most im	portant technologies and	d materials of MEMS as well as	their application	ons in sensors and
	actuators.					
Ckilla	Chudonto oro oblo to	analyse and day	assiba tha functional ha	havious of MEMC components		a the netential of
SKIIIS		analyze and des	scribe the functional be	haviour of MEMS components	and to evaluat	e the potential of
	microsystems.					
Personal Competence						
Social Competence	Students are able to so	olve specific prob	lems alone or in a group	and to present the results accord	lingly.	
Autonomy		cquire particular	knowledge using special	ized literature and to integrate a	and associate ti	nis knowledge with
	other fields.					
Workload in Hours	Independent Study Tin	ne 124, Study Tin	ne in Lecture 56			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	No 10 %	Presentation				
Examination	Written exam					
Examination duration and	2h					
scale						
Assignment for the	Electrical Engineering:	Core qualification	n: Compulsory			
Following Curricula	International Managen	nent and Enginee	ring: Specialisation II. Ele	ctrical Engineering: Elective Com	npulsory	
	International Managen	nent and Enginee	ring: Specialisation II. Me	chatronics: Elective Compulsory		
	_			cronics: Elective Compulsory		
		-	sign: Elective Compulsor	•		
		-	e qualification: Elective C	, ,		
				Course: Elective Compulsory		
	Theoretical Mechanica	l Engineering: Spe	ecialisation Bio- and Med	ical Technology: Elective Compul	sory	

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

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

Module M0806: Techr	nical Acoustics II (Room Acoustics, Co	omputational Methods)		
Courses				
Title		Тур	Hrs/wk	СР
Technical Acoustics II (Room Acous	tics, Computational Methods) (L0519)	Lecture	2	3
Technical Acoustics II (Room Acous	tics, Computational Methods) (L0521)	Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Technical Acoustics I (Acoustic Waves, Noise Protection	on, Psycho Acoustics)		
Knowledge	Machanias I (Chatias Machanias of Matavials) and Mac	shoping II / I I I depotation Kingmating Duna	mai an \	
	Mechanics I (Statics, Mechanics of Materials) and Mec	nanics ii (nydrostatics, Kinematics, Dyna	imics)	
	Mathematics I, II, III (in particular differential equation	ns)		
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge in aco	ustics regarding room acoustics and con	nputational meth	nods and are able to
	give an overview of the corresponding theoretical and	d methodical basis.		
SKIIIS	kills The students are capable to handle engineering problems in acoustics by theory-based application of the demand			of the demanding
	computational methods and procedures treated withi	n the module.		
Personal Competence				
Social Competence	Students can work in small groups on specific probler	ms to arrive at joint solutions.		
Autonomy	The students are able to independently solve challe	enging acoustical problems in the areas	treated within t	he module. Possible
, ,	conflicting issues and limitations can be identified and	,		
	-	*		
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20-30 Minuten			
scale				
Assignment for the	Aircraft Systems Engineering: Core qualification: Elec	tive Compulsory		
Following Curricula	Aircraft Systems Engineering: Specialisation Cabin Sy	stems: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective	Compulsory		
	Product Development, Materials and Production: Core	qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Compl	ementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Pr	oduct Development and Production: Elec	tive Compulsory	

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

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

Module M0832: Adva	nced Topics in Control			
Courses				
Title		Тур	Hrs/wk	СР
Advanced Topics in Control (L0661)	Lecture	2	3
Advanced Topics in Control (L0662)	Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, lir	near matrix inequalities		
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	Students can explain the advantages and short	comings of the classical gain scheduling	ı annroach	
	They can explain the representation of nonline.			
	They can explain how stability and performance			onditions
	They can explain how gridding techniques can	be used to solve analysis and synthesis	problems for LPV	systems
	 They are familiar with polytopic and LFT representations. 	presentations of LPV systems and som	e of the basic s	synthesis techniques
	associated with each of these model structures	;		
	Students can explain how graph theoretic columns	oncepts are used to represent the co	mmunication top	ology of multiagent
	systems			
	They can explain the convergence properties o			
	 They can explain analysis and synthesis condit 	ions for formation control loops involving	g either LTI or LP\	/ agent models
	Students can explain the state space represent to an actuator/conservers.	tation of spatially invariant distributed s	ystems that are o	discretized according
	to an actuator/sensor array They can explain (in outline) the extension o	f the hounded real lemma to such dis	tributed systems	and the associated
	synthesis conditions for distributed controllers	the bounded real leffind to such dis	tributed systems	and the associated
	,			
Skills	Students are capable of constructing LPV mo	odels of nonlinear plants and carry ou	t a mixed-sensit	ivity design of gain-
	scheduled controllers; they can do this using p	olytopic, LFT or general LPV models		
	They are able to use standard software tools (N	Matlab robust control toolbox) for these t	asks	
	 Students are able to design distributed forma 	tion controllers for groups of agents w	ith either LTI or L	PV dynamics, using
	Matlab tools provided			
	Students are able to design distributed controll	ers for spatially interconnected systems	, using the Matla	b MD-toolbox
Personal Competence				
Social Competence	Students can work in small groups and arrive at joint	results.		
Autonomy	Students are able to find required information in sour	ces provided (lecture notes, literature, s	oftware docume	ntation) and use it to
	solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	56		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
_	Electrical Engineering: Specialisation Control and Pow		uisory	
Following Curricula		•		
	Aircraft Systems Engineering: Specialisation Aircraft S Aircraft Systems Engineering: Core qualification: Elect			
	International Management and Engineering: Specialis		orv	
	Mechatronics: Specialisation System Design: Elective	·		
	Mechatronics: Specialisation Intelligent Systems and I			
	Biomedical Engineering: Specialisation Implants and I	• •		
	Biomedical Engineering: Specialisation Medical Techn		oulsory	
	Biomedical Engineering: Specialisation Management	and Business Administration: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: Elective (Compulsory	
	Theoretical Mechanical Engineering: Technical Compl			
	Theoretical Mechanical Engineering: Specialisation Ro	botics and Computer Science: Elective (Compulsory	

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

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

Module M1024: Metho	ods of Integrated Product Deve	elopment		
Courses				
Title		Тур	Hrs/wk	СР
Integrated Product Development II		Lecture	3	3
Integrated Product Development II	(L1255)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Dieter Krause			
Admission Requirements	None			
Recommended Previous	Basic knowledge of Integrated product development	opment and applying CAE systems		
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	After passing the module students are able to	0:		
	 explain technical terms of design meth 	hodology		
	describe essential elements of constru			
		rent state of research of integrated product develo	nment	
			,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
Skills	After passing the module students are able to	0:		
	select and apply proper construction	methods for non-standardized solutions of proble	ms as well as	adant new boundar
	conditions,	methods for horr standardized solutions of problem	nis as wen as	adapt new bodinadi
	· ·	with the assistance of a workshop based approach,		
	choose and execute appropriate mode			
		4		
Personal Competence				
Social Competence	After passing the module students are able to	0:		
	prepare and lead team meetings and r	moderation processes.		
	 work in teams on complex tasks, 			
	represent problems and solutions and	advance ideas.		
Autonomy	After passing the module students are able to	0:		
	 give a structured feedback and accept 	t a critical feedback,		
	implement the accepted feedback auto			
Workload in Hours	Independent Study Time 110, Study Time in	Lecture 70		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 Minuten			
scale				
Assignment for the	Aircraft Systems Engineering: Specialisation	Cabin Systems: Elective Compulsory		
Following Curricula	Aircraft Systems Engineering: Specialisation	Air Transportation Systems: Elective Compulsory		
	Aircraft Systems Engineering: Core qualificati	ion: Elective Compulsory		
		Specialisation II. Product Development and Product	ion: Elective C	ompulsory
	Mechatronics: Specialisation System Design:			
	· ·	ion: Specialisation Product Development: Compulso	-	
	· · · · · · · · · · · · · · · · · · ·	ion: Specialisation Production: Elective Compulsory		
	' '	ion: Specialisation Materials: Elective Compulsory		
		al Complementary Course: Elective Compulsory	.a. Cama:-::!	
	Theoretical Mechanical Engineering: Specialis	sation Product Development and Production: Electi	ve Compulsory	

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

Course L1255: Integrated Product Development II		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Dieter Krause	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Springer 2013.

Module M1173: Appli	d Statistics			
Courses				
Title		Тур	Hrs/wk	СР
Applied Statistics (L1584)		Lecture	2	3
Applied Statistics (L1586)		Project-/problem-based Lea	rning 2	2
Applied Statistics (L1585)		Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of statistical metho	ds		
Knowledge				
Educational Objectives	After taking part successfully, stude	nts have reached the following learning results		
Professional Competence				
Knowledge	Students can explain the statistical r	nethods and the conditions of their use.		
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results			
Personal Competence				
Social Competence	Team Work, joined presentation of re	esults		
Autonomy	To understand and interpret the que	stion and solve		
Workload in Hours	Independent Study Time 110, Study	Time in Lecture 70		
Credit points	6			
Course achievement	Compulsory Bonus Form	Description		
	Yes None Written elabo	ration		
Examination	Written exam			
Examination duration and	90 minutes, 28 questions			
scale				
Assignment for the	Mechanical Engineering and Manage	ment: Specialisation Management: Elective Compulsor	У	
Following Curricula	Mechatronics: Specialisation System	Design: Elective Compulsory		
	Mechatronics: Specialisation Intellige	nt Systems and Robotics: Elective Compulsory		
	Biomedical Engineering: Core qualifi	cation: Compulsory		
	Product Development, Materials and	Production: Core qualification: Elective Compulsory		
	Theoretical Mechanical Engineering:	Technical Complementary Course: Elective Compulsor	у	
	Theoretical Mechanical Engineering:	Specialisation Bio- and Medical Technology: Elective C	ompulsory	

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

Course L1586: Applied Statis	stics
Тур	Project-/problem-based Learning
Hrs/wk	2
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	stics
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	WiSe
Content	The different statistical tests are applied for the solution of realistic problems using actual data sets and the most common used commercial statistical software package (SPSS).
Literature	Student Solutions Manual for Kleinbaum/Kupper/Muller/Nizam's Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University Lawrence L. Kupper University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University, Published by Duxbury Press, Paperbound © 1998, ISBN/ISSN: 0-534-20913-0

Module M1204: Mode	lling and Optimization in Dynamics			
Courses				
Title Flexible Multibody Systems (L1632)	Typ Lecture	Hrs/wk	CP 3
Optimization of dynamical systems		Lecture	2	3
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous Knowledge	Mathematics I, II, III Mechanics I, II, III, IV Simulation of dynamical Systems			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
	Students demonstrate basic knowledge and understan multibody systems and methods for optimizing dynamic Students are able			x rigid and flexible
JAIIIS	+ to think holistically + to independently, securly and critically analyze and systems + to describe dynamics problems mathematically + to optimize dynamics problems	optimize basic problems of	the dynamics of rigid and	d flexible multibody
Personal Competence Social Competence	Students are able to + solve problems in heterogeneous groups and to docur	ment the corresponding resul	lts.	
Autonomy	Students are able to + assess their knowledge by means of exercises. + acquaint themselves with the necessary knowledge to	solve research oriented tasi	ks.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
Examination				
Examination duration and scale	30 min			
Assignment for the Following Curricula	1	e Compulsory tems: Elective Compulsory mpulsory ootics: Elective Compulsory ualification: Elective Compuls Elective Compulsory		

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

Course L1633: Optimization	of dynamical systems
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
Language	DE
Cycle	WiSe
Content	1. Formulation and classification of optimization problems 2. Scalar Optimization 3. Sensitivity Analysis 4. Unconstrained Parameter Optimization 5. Constrained Parameter Optimization 6. Stochastic optimization 7. Multicriteria Optimization 8. 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 M1268: Linea	r and Nonlinear Waves			
Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear Waves (L1737	7)	Project-/problem-based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Good Knowledge in Mathematics, Mechanics and Dyna	mics.		
Knowledge				
Educational Objectives	After taking part successfully, students have reached to	the following learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts in	Wave Mechanics and to develop and research	new terms and	concepts.
Skills	Students are able to apply existing methods and procesure	s of Wave Mechanics and to develop novel met	thods and proce	edures.
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks individual	ually and to identify and follow up novel resear	ch tasks by the	mselves.
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	2 Hours			
scale				
Assignment for the	Mechatronics: Specialisation System Design: Elective 0	Compulsory		
Following Curricula	Naval Architecture and Ocean Engineering: Core qualit	ication: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Ma	3, , ,		
	Theoretical Mechanical Engineering: Technical Comple	mentary Course: Elective Compulsory		

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

Module M1229: Contr	ol Lab B			
Courses				
Title Control Lab V (L1667) Control Lab VI (L1668)		Typ Practical Course Practical Course	Hrs/wk 1 1	CP 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 reach	ned the following learning results		
Professional Competence Knowledge	Students can explain the difference between	n validation of a control lop in simulatic	on and experimental v	validation
Skills	 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers 			
Personal Competence Social Competence	Students can work in teams to conduct exp.	eriments and document the results		
Autonomy	Students can independently carry out simul	ation studies to design and validate con	ntrol loops	
Workload in Hours	Independent Study Time 32, Study Time in Lecture	e 28		
Credit points	2			
Course achievement	None			
Examination	Written elaboration			
Examination duration and scale	1			
Assignment for the	Electrical Engineering: Specialisation Control and F	Power Systems Engineering: Elective Co	ompulsory	
Following Curricula	Mechatronics: Specialisation Intelligent Systems at Mechatronics: Specialisation System Design: Elect			

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

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

nar Advanced Topics in Control			
	Typ Seminar	Hrs/wk	CP 2
Prof. Herbert Werner			
None			
Introduction to control systems Control theory and design optimal and robust control			
After taking part successfully, students have reached	d the following learning results		
Students can explain modern control. Students learn to apply basic control concepts	s for different tasks		
 Students acquire knowledge about selected aspects of modern control, based on specified literature Students generalize developed results and present them to the participants Students practice to prepare and give a presentation 			
	•	of their own results	
solution	·	·	
Independent Study Time 32, Study Time in Lecture 2	28		
2			
None			
Presentation			
90 min			
, , , , , , , , , , , , , , , , , , , ,			
	Prof. Herbert Werner None Introduction to control systems Control theory and design optimal and robust control After taking part successfully, students have reached Students can explain modern control. Students learn to apply basic control concepts Students acquire knowledge about selected a Students generalize developed results and processed and students practice to prepare and give a prese Students are capable of developing solutions They are able to provide appropriate feedback Students familiarize themselves with a scient such that a scientific discussion develops Independent Study Time 32, Study Time in Lecture 22 None Presentation 90 min	Prof. Herbert Werner None Introduction to control systems Control theory and design optimal and robust control After taking part successfully, students have reached the following learning results Students can explain modern control. Students learn to apply basic control concepts for different tasks Students acquire knowledge about selected aspects of modern control, based on Students generalize developed results and present them to the participants Students practice to prepare and give a presentation Students are capable of developing solutions and present them They are able to provide appropriate feedback and handle constructive criticism Students evaluate advantages and drawbacks of different forms of presenta solution Students familiarize themselves with a scientific field, are able of introduce it such that a scientific discussion develops Independent Study Time 32, Study Time in Lecture 28 None Presentation	Typ Hrs/wk Seminar 2 Prof. Herbert Werner None Introduction to control systems Control theory and design optimal and robust control After taking part successfully, students have reached the following learning results Students can explain modern control. Students learn to apply basic control concepts for different tasks Students acquire knowledge about selected aspects of modern control, based on specified literature Students generalize developed results and present them to the participants Students practice to prepare and give a presentation Students are capable of developing solutions and present them They are able to provide appropriate feedback and handle constructive criticism of their own results Students evaluate advantages and drawbacks of different forms of presentation for specific tasks solution Students familiarize themselves with a scientific field, are able of introduce it and follow presentation such that a scientific discussion develops Independent Study Time 32, Study Time in Lecture 28 None Presentation 90 min Mechatronics: Specialisation System Design: Elective Compulsory

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

Module M1398: Selec	ted Topics in Multibody Dynamics and	Robotics		
Courses				
Title		Тур	Hrs/wk	СР
Formulas and Vehicles - Mathemati	ics and Mechanics in Autonomous Driving (L1981)	Project-/problem-based Learning	2	6
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous	Mechanics IV, Applied Dynamics or Robotics			
Knowledge	Numerical Treatment of Ordinary Differential Equations			
	Control Systems Theory and Design			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				
Knowledge	After successful completion of the module students de areas of multibody dynamics and robotics	emonstrate deeper knowledge and unde	erstanding in	selected application
Skills	Students are able			
	+ to think holistically			
	+ to independently, securly and critically analyze and systems	optimize basic problems of the dynami	ics of rigid a	nd flexible multibody
	+ 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 docur	nent the corresponding results and prese	ent them	
Autonomy	Students are able to			
	+ assess their knowledge by means of exercises and pro	jects.		
	+ acquaint themselves with the necessary knowledge to	solve research oriented tasks.		
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28			
Credit points	6		-	
Course achievement	None			
Examination	Presentation			
Examination duration and	ТВА			
scale				
Assignment for the	Mechatronics: Specialisation Intelligent Systems and Rob			
Following Curricula	Mechatronics: Specialisation System Design: Elective Co			
	Theoretical Mechanical Engineering: Technical Complem			
	Theoretical Mechanical Engineering: Core qualification: E	elective Compulsory		

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

Module M0881: Mathe	ematical Image Processing			
Courses				
Title		Тур	Hrs/wk	СР
Mathematical Image Processing (LC	0991)	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, gradien			
	Linear Algebra: eigenvalues, least so	quares solution of a linear system		
Educational Objectives	After taking part successfully, students have	ve reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	the second secon			
	characterize and compare diffusion			
	 explain elementary methods of imag explain methods of image segmenta 	• •		
	sketch and interrelate basic concept			
	sketch and interrelate basic concept	s of functional analysis		
Skills	Students are able to			
	implement and apply elementary me	ethods of image processing		
	explain and apply modern methods	of image processing		
Personal Competence				
Social Competence	Students are able to work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge) and to explain theoretical foundations.			
	background knowledge) and to explain the	oretical foundations.		
Autonomy				
	,	neir understanding of complex concepts on the	ir own. They can sp	ecify open questions
	precisely and know where to get hel			k. d
	· ·	persistence to be able to work for longer per	iods in a goai-orien	ited manner on nard
	problems.			
Workload in Hours	Independent Study Time 124, Study Time i	n Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Bioprocess Engineering: Specialisation A - 0	General Bioprocess Engineering: Elective Compu	ulsory	
Following Curricula	Computer Science: Specialisation III. Mathe	ematics: Elective Compulsory		
		pecialisation III. Mathematics: Elective Compulso		
	, , ,	on Computational Methods in Biomedical Imagin	g: Compulsory	
	Mechatronics: Technical Complementary C			
	Mechatronics: Specialisation System Desig			
	Mechatronics: Specialisation Intelligent Sys			
	Technomathematics: Specialisation I. Math			
		ical Complementary Course: Elective Compulsor		
		alisation Robotics and Computer Science: Electiv	e Compulsory	
	Process Engineering: Specialisation Process	s Engineering: Elective Compulsory		

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

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

Module M1048: Integ	rated Circuit Design			
Courses				
Title		Тур	Hrs/wk	СР
Integrated Circuit Design (L0691)		Lecture	3	4
Integrated Circuit Design (L0998)		Recitation Section (small)	1	2
Module Responsible	Prof. Matthias Kuhl			
Admission Requirements	None			
Recommended Previous	Basic knowledge of (solid-state) physics and mather	natics.		
Knowledge	Knowledge in fundamentals of electrical engineering	and electrical networks.		
Educational Objectives	After taking part successfully, students have reached	d the following learning results		
Professional Competence Knowledge		oles of pn-diodes, MOS capacitors, and MC cage relationships and small-signal equivace voltage behavior transistors based on chets for static and dynamic logic gates for incomer consumption on the device and circustions of analytical expression for device a	semiconductor de DSFETs using ener Ment circuits of th arged carrier flow ntegrated circuits uit level	evice equations). rgy band diagrams. lese devices.
Skills	Students can qualitatively construct energy b Students are able to qualitatively determin diagrams. Students can understand scientific publication Students can calculate the dimensions of MOS Students can design complex electronic circui Students know procedure for optimization reg	e electric field, carrier concentrations, as from the field of semiconductor devices devices in dependence of the circuits prots and anticipate possible problems.	and charge flow s. operties	r from energy band
Personal Competence Social Competence Autonomy		mall groups for solving problems and ans the value of their contributions to workin n a realistic manner.		stions.
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelectronic	s and Microsystems Technology: Elective	Compulsory	
Following Curricula	'			
•	Mechanical Engineering and Management: Specialise		. ,	
		• • •		
	Mechatronics: Specialisation System Design: Elective	e Compulsory		

Course L0691: Integrated Cir	rcuit Design
Тур	Lecture
Hrs/wk	3
СР	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	ourse L0998: Integrated Circuit Design	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Matthias Kuhl	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Supplement Modules

Module M0604: High-					
Courses					
Title			Тур	Hrs/wk	СР
High-Order FEM (L0280)			Lecture	3	4
High-Order FEM (L0281)	1		Recitation Section (large)	1	2
Module Responsible	Prof. Alexander Düster				
Admission Requirements	None				
Recommended Previous	Knowledge of partial differe	ial equations is rec	ommended.		
Knowledge					
Educational Objectives	After taking part successful	, students have rea	ched the following learning results		
Professional Competence					
Knowledge					
	+ give an overview of the d		te element procedures.		
	+ explain high-order finite e	ement procedures.			
	+ specify problems of finit	element procedure	es, to identify them in a given situation	and to explain the	eir mathematical an
	mechanical background.				
Skills	Students are able to				
55	+ apply high-order finite ele	nents to problems o	f structural mechanics.		
		·	nics a suitable finite element procedure.		
	+ critically judge results of		·		
	+ transfer their knowledge	-			
Personal Competence					
Social Competence	Students are able to				
	+ solve problems in heterog	neous groups and t	o document the corresponding results.		
Autonomy	Students are able to				
raconomy	+ assess their knowledge by	means of exercises	and F-I earning		
			ledge to solve research oriented tasks.		
	T dequatite aremberres man	The medeasary known	leage to solve research sherical tasks.		
Workload in Hours	Independent Study Time 12	Study Time in Lect	ture 56		
Credit points	6				
Course achievement	Compulsory Bonus Form		Description		
		ntation	Forschendes Lernen		
Examination					
Examination duration and	120 min				
scale					
Assignment for the	Energy Systems: Core quali-		•		
Following Curricula			cialisation II. Product Development and Pr	oduction: Elective (Compulsory
	Materials Science: Specialis	_			
			alisation Product Development and Produc	ction: Elective Com	pulsory
	Mechatronics: Technical Cor		• •		
	•		Core qualification: Elective Compulsory		
			qualification: Elective Compulsory		
	Technomathematics: Specia	sation III. Engineeri	ng Science: Elective Compulsory		
	Theoretical Mechanical Engi	eering: Technical Co	omplementary Course: Elective Compulso	ry	
	Theoretical Mechanical Engi	eering: Core qualific	cation: Elective Compulsory		

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

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

Module M0605: Comp	outational Structural Dynamics					
Courses						
Title		Тур	Hrs/wk	СР		
Computational Structural Dynamics		Lecture	3	4		
Computational Structural Dynamics	T	Recitation Section (small)	1	2		
Module Responsible	Prof. Alexander Düster					
Admission Requirements	None					
	Knowledge of partial differential equations is r	ecommended.				
Knowledge						
Educational Objectives	After taking part successfully, students have re	eached the following learning results				
Professional Competence						
Knowledge	Students are able to					
	+ give an overview of the computational proce	•				
	+ explain the application of finite element pro					
	+ specify problems of computational structure	al dynamics, to identify them in a given situa	ation and to explai	n their mathematical		
	and mechanical background.					
Skills	Students are able to					
	+ model problems of structural dynamics.					
	+ select a suitable solution procedure for a giv	ven problem of structural dynamics.				
	+ apply computational procedures to solve pro	+ apply computational procedures to solve problems of structural dynamics.				
	+ verify and critically judge results of computational structural dynamics.					
Personal Competence						
Social Competence	Students are able to					
	+ solve problems in heterogeneous groups an	d to document the corresponding results.				
Autonomy	Students are able to					
	+ acquire independently knowledge to solve c	complex problems.				
Workload in Hours	Independent Study Time 124, Study Time in Lo	ecture 56				
Credit points	6					
Course achievement	None					
Examination	Written exam					
Examination duration and	2h					
scale						
Assignment for the	International Management and Engineering: S	pecialisation II. Mechatronics: Elective Compu	Isory			
Following Curricula	Materials Science: Specialisation Modeling: Ele	ective Compulsory				
	Mechatronics: Technical Complementary Cours	se: Elective Compulsory				
	Naval Architecture and Ocean Engineering: Co	ore qualification: Elective Compulsory				
	Theoretical Mechanical Engineering: Technical	Complementary Course: Elective Compulsory	/			
	Theoretical Mechanical Engineering: Specialisa	ation Simulation Technology: Elective Compul	sory			

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

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

Module M0673: Inform	mation Theory and Coding			
Courses				
Title Information Theory and Coding (L0 Information Theory and Coding (L0		Typ Lecture Recitation Section (large)	Hrs/wk 3 2	CP 4 2
Module Responsible		Nechation Section (large)		-
Admission Requirements				
Recommended Previous Knowledge	Mathematics 1-3			
Educational Objectives	After taking part successfully, students have reached the follow	ving learning results		
Professional Competence				
	The students know the basic definitions for quantification of information in the sense of information theory. They know Shannon's source coding theorem and channel coding theorem and are able to determine theoretical limits of data compression and error-free data transmission over noisy channels. They understand the principles of source coding as well as error-detecting and error-correcting channel coding. They are familiar with the principles of decoding, in particular with modern methods of iterative decoding. They know fundamental coding schemes, their properties and decoding algorithms. The students are able to determine the limits of data compression as well as of data transmission through noisy channels and based on those limits to design basic parameters of a transmission scheme. They can estimate the parameters of an error-detecting or error-correcting channel coding scheme for achieving certain performance targets. They are able to compare the properties of basic channel coding and decoding schemes regarding error correction capabilities, decoding delay, decoding complexity and to decide for a suitable method. They are capable of implementing basic coding and decoding schemes in software.			
Personal Competence				
Social Competence	The students can jointly solve specific problems.			
Autonomy	The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems, software tools, clicker system.			control their level of
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70	-		
Credit points	6			
Course achievement	None			
Examination				
Examination duration and	90 min			
scale				
Assignment for the			-	
Following Curricula	Computational Science and Engineering: Specialisation II. Engin		uisory	
	Information and Communication Systems: Core qualification: C International Management and Engineering: Specialisation II. E Mechatronics: Technical Complementary Course: Elective Com	lectrical Engineering: Elective C	ompulsory	

Course L0436: Information T	heory and Coding			
Тур	Lecture			
Hrs/wk	3			
СР	4			
Workload in Hours	dependent Study Time 78, Study Time in Lecture 42			
	of. Gerhard Bauch			
Language				
Cycle	SoSe SoSe SoSe SoSe SoSe SoSe SoSe SoSe			
Content	Fundamentals of information theory			
	Self information, entropy, mutual information			
	Source coding theorem, channel coding theorem			
	Channel capacity of various channels			
	Fundamental source coding algorithms:			
	Huffman Code, Lempel Ziv Algorithm			
	Fundamentals of channel coding			
	 Basic parameters of channel coding and respective bounds Decoding principles: Maximum-A-Posteriori Decoding, Maximum-Likelihood Decoding, Hard-Decision-Decoding ar Soft-Decision-Decoding 			
	Error probability			
	Block codes			
	Low Density Parity Check (LDPC) Codes and iterative Ddecoding			
	Convolutional codes and Viterbi-Decoding			
	Turbo Codes and iterative decoding			
	Coded Modulation			
Literature	Bossert, M.: Kanalcodierung. Oldenbourg.			
	Friedrichs, B.: Kanalcodierung. Springer.			
	Lin, S., Costello, D.: Error Control Coding. Prentice Hall.			
	Roth, R.: Introduction to Coding Theory.			
	Johnson, S.: Iterative Error Correction. Cambridge.			
	Richardson, T., Urbanke, R.: Modern Coding Theory. Cambridge University Press.			
	Gallager, R. G.: Information theory and reliable communication. Whiley-VCH			
	Cover, T., Thomas, J.: Elements of information theory. Wiley.			

Course L0438: Information Theory and Coding		
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	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0769: EMC I	: Coupling Mechanisms,	. Countermeasures a	and Test Procedures	}	
Courses					
Title		Тур	Hrs/wk	СР	
	termeasures, and Test Procedures (LO		Lecture	3	4
: =	termeasures, and Test Procedures (LO: termeasures, and Test Procedures (LO:		Recitation Section (small) Practical Course	1 1	1
	Prof. Christian Schuster	743)	riactical course	1	1
Admission Requirements					
Recommended Previous		erina			
Knowledge		9			
Educational Objectives	After taking part successfully, stud	lents have reached the followi	ng learning results		
Professional Competence					
Knowledge	Students are able to explain the fundamental principles, inter-dependencies, and methods of Electromagnetic Compatibility of electric and electronic systems and to ensure Electromagnetic Compatibility of such systems. They are able to classify and explain the common interference sources and coupling mechanisms. They are capable of explaining the basic principles of shielding and filtering. They are able of giving an overview over measurement and simulation methods for the characterization of Electromagnetic Compatibility in electrical engineering practice.				
Skills	Students are able to apply a series of modeling methods for the Electromagnetic Compatibility of typical electric and electronic systems. They are able to determine the most important effects that these models are predicting in terms of Electromagnetic Compatibility. They can classify these effects and they can quantitatively analyze them. They are capable of deriving problem solving strategies from these predictions and they can adapt them to applications in electrical engineering practice. They can evaluate their problem solving strategies against each other.				
Personal Competence					
Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English, during laboratory work and exercises, e.g				
Autonomy	Students are capable to gather necessary information from the references provided and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. Theoretical Electrical Engineering and Communication Theory). They can communicate problems and solutions in the field of Electromagnetic Compatibility in english language.				
Workload in Hours	Independent Study Time 110, Stud	dy Time in Lecture 70			
Credit points	6			·	
Course achievement	Compulsory Bonus Form Yes None Presentation	Description n			
Examination	Oral exam				
Examination duration and	45 min				
scale					
Assignment for the	Electrical Engineering: Specialisati	on Microwave Engineering, Op	tics, and Electromagnetic Co	mpatibility: Elect	tive Compulsory
Following Curricula	· ·		•		
	Microelectronics and Microsystems	s: Specialisation Microelectron	ics Complements: Elective Co	mpulsory	

Course L0743: EMC I: Couplin	ng Mechanisms, Countermeasures, and Test Procedures
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	 Introduction to Electromagnetic Compatibility (EMC) Interference sources in time an frequency domain Coupling mechanisms Transmission lines and coupling to electromagnetic fields Shielding Filters EMC test procedures
Literature	 C.R. Paul: "Introduction to Electromagnetic Compatibility", 2nd ed., (Wiley, New Jersey, 2006). A.J. Schwab und W. Kürner: "Elektromagnetische Verträglichkeit", 6. Auflage, (Springer, Berlin 2010). F.M. Tesche, M.V. Ianoz, and T. Karlsson: "EMC Analysis Methods and Computational Models", (Wiley, New York, 1997).

Course L0744: EMC I: Couplin	ng Mechanisms, Countermeasures, and Test Procedures
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	The exercise sessions serve to deepen the understanding of the concepts of the lecture.
Literature	 C.R. Paul: "Introduction to Electromagnetic Compatibility", 2nd ed., (Wiley, New Jersey, 2006). A.J. Schwab und W. Kürner: "Elektromagnetische Verträglichkeit", 6. Auflage, (Springer, Berlin 2010). F.M. Tesche, M.V. Ianoz, and T. Karlsson: "EMC Analysis Methods and Computational Models", (Wiley, New York, 1997). Scientific articles and papers

Course L0745: EMC I: Coupling Mechanisms, Countermeasures, and Test Procedures		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	SoSe	
Content	Laboratory experiments serve to practically investigate the following EMC topics:	
	Shielding Conducted EMC test procedures The GTEM-cell as an environment for radiated EMC test	
Literature	Versuchsbeschreibungen und zugehörige Literatur werden innerhalb der Veranstaltung bereit gestellt.	

Module M0924: Softw	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 (small)	3	3
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous Knowledge	Good knowledge and experience in programming language C Basis knowledge in software engineering Basic understanding of assembly language			
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
	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 concrete microcontroller. The participants explain requirements of real time systems. They know at least three scheduling algorithms for real time operating systems including their pros and cons. Students build interrupt-based programs for a concrete microcontroller. They build and use a preemptive scheduler. They use peripheral components (timer, ADC, EEPROM) to realize complex tasks for embedded systems. To interface with external components they utilize serial protocols.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 110, Study Time in Lectu	ire 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min	·		
scale				
Assignment for the	Mechatronics: Technical Complementary Course:	Elective Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems a	nd Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elect	ive Compulsory		
	Microelectronics and Microsystems: Specialisation	Embedded Systems: Elective Compulso	ry	

Course L1069: Software for I	mbdedded 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 Embdedded Systems	
Тур	Recitation Section (small)
Hrs/wk	3
СР	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		Тур	Hrs/wk	СР
Compilers for Embedded Systems (Compilers for Embedded Systems (Lecture	3 arning 1	4 2
		Project-/problem-based Lea	irning 1	2
Module Responsible				
Admission Requirements	None			
	Module "Embedded Systems"			
Knowledge	C/C++ Programming skills			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	Knowledge The relevance of embedded systems increases from year to year. Within such systems, the amount of software to be embedded processors grows continuously due to its lower costs and higher flexibility. Because of the particular appli of embedded systems, highly optimized and application-specific processors are deployed. Such highly specialized impose high demands on compilers which have to generate code of highest quality. After the successful attendance of the students are able • to illustrate the structure and organization of such compilers,		ular application are pecialized processo	
	to distinguish and explain intermediatto assess optimizations and their under	re representations of various abstraction levels erlying problems in all compiler phases.	s, and	
	The high demands on compilers for ember particular,	dded systems make effective code optimiza	tions mandatory. T	he students learn
	 which kinds of optimizations are applience how the translation from source code which kinds of optimizations are applience how register allocation is performed, how memory hierarchies can be explo 	to assembly code is performed, cable at the assembly code level, and		
		n have to optimize for multiple objectives (e.g learn to evaluate the influence of optimization		
Skills	·	tudents shall be able to translate high-level pri imization should be applied most effectively a	_	-
	While attending the labs, the students will le	earn to implement a fully functional compiler in	ncluding optimizatio	ons.
Personal Competence				
Social Competence	Students are able to solve similar problems a	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 k	nowledge with oth	er 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		er and Software Engineering: Elective Compuls	,	
Following Curricula	Electrical Engineering: Specialisation Informa	ation and Communication Systems: Elective Co	ompulsory	
	Aircraft Systems Engineering: Core qualificat	· · ·		
	Mechatronics: Specialisation Intelligent Syste	ems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design:	• •		
	Mechatronics: Technical Complementary Cou	• •		
		al Complementary Course: Elective Compulso	-	
	Theoretical Mechanical Engineering: Speciali	sation Robotics and Computer Science: Elective	ve Compulsory	

Course L1692: Compilers for	Embedded Systems
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Heiko Falk
Language	DE/EN
Cycle	SoSe
Content	 Introduction and Motivation Compilers for Embedded Systems - Requirements and Dependencies Internal Structure of Compilers Pre-Pass Optimizations HIR Optimizations and Transformations Code Generation LIR Optimizations and Transformations Register Allocation WCET-Aware Compilation Outlook
Literature	 Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 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	ourse L1693: Compilers for Embedded Systems	
Тур	Project-/problem-based Learning	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Heiko Falk	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1281: Advanced Topics in Vibration				
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 foll	owing learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts of Advance	ed Vibrations and to develop and resea	arch new terms	and concepts.
Skills	Students are able to apply existing methods and procesures of Adv	vanced 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 an	d to identify and follow up novel resear	rch tasks by the	mselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Mechatronics: Specialisation System Design: Elective Compu	Isory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics	s: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective Co	mpulsory		
	Theoretical Mechanical Engineering: Technical Complementa	ry Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Product D	evelopment and Production: Electiv	e Compulsory	

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

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advantages and limitations, and to decide which technique to use for a concrete task. They will be able to apply these technic to practical problems. They obtain first experiences in hardware-related software development, in industry-relevant specifical 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 Credit points 6 Course achievement None Examination Written elaboration		
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		advantages and limitations, and to decide which technique to use for a concrete task. They will be able to apply these technique
Personal Competence Social 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		to practical problems. They obtain first experiences in hardware-related software development, in industry-relevant specification
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		tools and in the area of simple control applications.
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	Personal Competence	
Workload in Hours Independent Study Time 124, Study Time in Lecture 56 Credit points 6 Course achievement None Examination Written elaboration	Social Competence	Students are able to solve similar problems alone or in a group and to present the results accordingly.
Credit points 6 Course achievement None Examination Written elaboration	Autonomy	Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.
Course achievement None Examination Written elaboration	Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Examination Written elaboration	Credit points	6
	Course achievement	None
Examination duration and Execution and documentation of all lab experiments	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	Following Curricula	
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 Memgent Systems and Nobotics. Elective Compulsory		
Mechatronics: Technical Complementary Course: Elective Compulsory		

Course L1740: Lab Cyber-Phy	ysical Systems
Тур	Project-/problem-based Learning
Hrs/wk	4
СР	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 M0627: Mach	ine Learning and Data Mining			
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	Calculus			
	Stochastics			
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	Students can explain the difference between insta	ance-based and model-based learning app	roaches, and they	can enumerate basi
	machine learning technique for each of the to	wo basic approaches, either on the bas	sis of static data,	or on the basis of
	incrementally incoming data . For dealing with t	uncertainty, students can describe suitab	le representation f	ormalisms, and the
	explain how axioms, features, parameters, or s	tructures used in these formalisms can b	oe learned automa	tically with differer
	algorithms. Students are also able to sketch differ	rent clustering techniques. They depict ho	w the performance	of learned classifier
	can be improved by ensemble learning, and they	can summarize how this influences compu	utational learning t	heory. Algorithms fo
	reinforcement learning can also be explained by	students.		
Skills	Student derive decision trees and, in turn, prop	ositional rule sets from simple and static	data tables and a	re able to name an
	Student derive decision trees and, in turn, propositional rule sets from simple and static data tables and are able to name and explain basic optimization techniques. They present and apply the basic idea of first-order inductive leaning. Students apply the			
	BME, MAP, ML, and EM algorithms for learning pa	* * *	_	
	know how to carry out Gaussian mixture learn	ning. They can contrast kNN classifiers,	neural networks,	and support vector
	machines, and name their basic application area	as and algorithmic properties. Students ca	an describe basic o	lustering technique
	and explain the basic components of those tech	nniques. Students compare related mach	ine learning techn	iques, e.g., k-mean
	clustering and nearest neighbor classification.	They can distinguish various ensemble	learning technique	es and compare th
	different goals of those techniques.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours		ure 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	, , , , , , , , , , , , , , , , , , , ,			
Following Curricula			ive Compulsory	
	Mechatronics: Technical Complementary Course:			
	Mechatronics: Specialisation System Design: Elec			
	Mechatronics: Specialisation Intelligent Systems a			
	Theoretical Mechanical Engineering: Technical Co			
	Theoretical Mechanical Engineering: Specialisatio	n Robotics and Computer Science: Elective	Compulsory	

Course L0340: Machine Lear	ning and Data Mining
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, 14, 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	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Rainer Marrone	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1616: Flight	t Control Law Design and Application			
Courses				
Title Flight Control Law Design and Appl Flight Control Law Design and Appl		Typ Lecture Project-/problem-based Learning	Hrs/wk 2 2	CP 4 2
Module Responsible	Prof. Frank Thielecke			
Admission Requirements	None			
Recommended Previous	Basic Knowledge in:			
Knowledge	* Mathematics (Linear Algebra and ordinary differential equation	ns)		
	* Control Systems (Transfer functions and state space represent	ation)		
	* Mechanics (Rigid-body kinetics)			
	* Flight Mechanics			
Educational Objectives	After taking part successfully, students have reached the followi	ng learning results		
Professional Competence				
Knowledge	Students are able to:			
	* describe and understand flight dynamics models for control tas	sks		
	* assess handling qualities and understand the need for augmer	tation through control systems		
	* identify fundamental limitations on performance of control law	S		
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 requirement	nts 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 56			
Credit points	6			
Course achievement	None			
Examination				
Examination duration and	60 min			
scale	A. 66 . 5 6			
Assignment for the Following Curricula				
Following Curricula	Mechatronics: Specialisation System Design: Elective Compulsor Mechatronics: Technical Complementary Course: Elective Comp			
	. Technical Complementary Course. Elective Complementary			

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
Language	EN
Cycle	SoSe 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	ourse 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	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0629: Intell	igent Autonomous Agents and Cog	nitive 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 have reach	ned the following learning results		
Professional Competence				
Knowledge Skills	Students can explain the agent abstraction, defin (goals, utilities, environments). They can describe can be discussed in terms of decision problems world scenarios, students can summarize how Ba formalism in static and dynamic settings. In add settings, with and with complete access to the solving (partially observable) Markov decision pr. Students can identify techniques for simultaneou desired states. Students can explain coordination of equilibria, social choice functions, voting protocomost students can select an appropriate agent archites students can derive decision trees and apply bas networks/dynamic Bayesian networks and apply different sampling techniques for simplified agen best action or policies for concrete settings. In m states, e.g., Nash equilibria. For multi-agent decision the results.	the main features of environments. The and algorithms for solving these problem yesian networks can be employed as a k ition, students can define decision making state of the environment. In this context oblems, and they can recall techniques as localization and mapping, and can exproblems and decision making in a multiple, and mechanism design techniques. Eacture for concrete agent application scenic optimization techniques. For those apply bayesian reasoning for simple queries the scenarios. For simple and complex deculti-agent situations students will apply to	notion of adversarins. For dealing with nowledge representing procedures in sit, students can desfor measuring the viplain planning technagent setting in technagent setting in technagens. For simplifications they can alsion making students can alsion making students can find in the second	al agent cooperation in uncertainty in real-tation and reasoning mple and sequential cribe techniques for value of information. Iniques for achieving rm of different types and agent application also create Bayesian so name and apply the can compute the g different equilibria.
Porsonal Compotonso				
Personal Competence Social Competence	Students are able to discuss their solutions to prol	blems with others. They communicate in I	English	
	Students are able of checking their understanding			ns
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ire 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	Computer Science: Specialisation II: Intelligence E	ngineering: Elective Compulsory		
Following Curricula	International Management and Engineering: Speci	alisation II. Information Technology: Elect	ive Compulsory	
	Mechatronics: Technical Complementary Course:	Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems a	nd Robotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial O	rgans and Regenerative Medicine: Electiv	e Compulsory	
	Biomedical Engineering: Specialisation Implants a	nd Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Te	chnology and Control Theory: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation Manageme	ent and Business Administration: Elective	Compulsory	
	Theoretical Mechanical Engineering: Technical Co	mplementary Course: Elective Compulsor	у	
	Theoretical Mechanical Engineering: Specialisation	n Robotics and Computer Science: Elective	e Compulsory	

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

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

Module M0836: Comn	nunication Networks			
Courses				
Title		Тур	Hrs/wk	СР
Selected Topics of Communication	Networks (L0899)	Project-/problem-based Learning	2	2
Communication Networks (L0897)		Lecture	2	2
Communication Networks Excercise	e (L0898)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Andreas Timm-Giel			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamental stochastics Basic understanding of computer network:	s and/or communication technologies is benefici	al	
Educational Objectives	After taking part successfully, students have read	ched the following learning results		
Professional Competence				
Knowledge	Students are able to describe the principles and structures of communication networks in detail. They can explain the formal description methods of communication networks and their protocols. They are able to explain how current and complex communication networks work and describe the current research in these examples.			
Skills	Students are able to evaluate the performance of communication networks using the learned methods. They are able to work out problems themselves and apply the learned methods. They can apply what they have learned autonomously on further and new communication networks.			
Personal Competence				
Social Competence	Students are able to define tasks themselves in small teams and solve these problems together using the learned methods. They			
	can present the obtained results. They are able t	o discuss and critically analyse the solutions.		
Autonomy	Students are able to obtain the necessary expe	rt knowledge for understanding the functionalit	y and perfor	mance capabilities of
Ź	new communication networks independently.	y y		·
Workload in Hours	Independent Study Time 110, Study Time in Lect	ture 70		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	1.5 hours colloquium with three students, there	fore about 30 min per student. Topics of the col	loquium are	the posters from the
scale	previous poster session and the topics of the mo	dule.		
Assignment for the	Electrical Engineering: Specialisation Information	and Communication Systems: Elective Compuls	ory	
Following Curricula	Electrical Engineering: Specialisation Control and	Power Systems Engineering: Elective Compulso	ry	
	Aircraft Systems Engineering: Core qualification:	Elective Compulsory		
	Computational Science and Engineering: Special	isation I. Computer Science: Elective Compulsory	,	
	Information and Communication Systems: Specia	alisation Secure and Dependable IT Systems, Foo	us Networks:	Elective Compulsory
	Information and Communication Systems: Specia	alisation Communication Systems: Elective Comp	oulsory	
	International Management and Engineering: Spe	cialisation II. Information Technology: Elective Co	ompulsory	
	Mechatronics: Technical Complementary Course:			
	Microelectronics and Microsystems: Specialisatio	n Communication and Signal Processing: Elective	e Compulsory	1

Course L0899: Selected Topi	cs of Communication Networks
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Timm-Giel
Language	EN
Cycle	WiSe
Content	Example networks selected by the students will be researched on in a PBL course by the students in groups and will be presented
	in a poster session at the end of the term.
Literature	see lecture

Course L0897: Communication	on Networks
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Timm-Giel, DrIng. Koojana Kuladinithi
Language	EN
Cycle	WiSe
Content	
Literature	Skript des Instituts für Kommunikationsnetze Tannenbaum, Computernetzwerke, Pearson-Studium Further literature is announced at the beginning of the lecture.

Course L0898: Communication	Course L0898: Communication Networks Excercise		
Тур	Project-/problem-based Learning		
Hrs/wk	1		
СР	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Andreas Timm-Giel		
Language	EN		
Cycle	WiSe		
Content	Part of the content of the lecture Communication Networks are reflected in computing tasks in groups, others are motivated and		
	addressed in the form of a PBL exercise.		
Literature	announced during lecture		

Module M0881: Mathe	ematical Image Processing			
Courses				
Title		Тур	Hrs/wk	СР
Mathematical Image Processing (LC	991)	Lecture	3	4
Mathematical Image Processing (LC	992)	Recitation Section (small)	1	2
Module Responsible	Prof. Marko Lindner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Analysis: partial derivatives, gradient			
	Linear Algebra: eigenvalues, least squ	uares solution of a linear system		
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	ali ana akani ana ana ana ana alista ali ana			
	characterize and compare diffusion e			
	 explain elementary methods of image explain methods of image segmentat 	·		
	 sketch and interrelate basic concepts 			
	Sketch and interrelate basic concepts	of functional analysis		
Skills	Students are able to			
	 implement and apply elementary me 	thods of image processing		
	 explain and apply modern methods o 	- · · · · · · · · · · · · · · · · · · ·		
	explain and apply modern methods o	i mage processing		
Personal Competence				
Social Competence	Students are able to work together in	heterogeneously composed teams (i.e., teams	from different s	tudy programs and
	background knowledge) and to explain theo	retical foundations.		
Autonomy				
,	 Students are capable of checking the 	eir understanding of complex concepts on their o	own. They can sp	ecify open questions
	precisely and know where to get help			
	·	persistence to be able to work for longer period	ls in a goal-orien	ted manner on hard
	problems.			
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Bioprocess Engineering: Specialisation A - G	eneral Bioprocess Engineering: Elective Compuls	ory	
Following Curricula	Computer Science: Specialisation III. Mather			
-	Computational Science and Engineering: Sp	ecialisation III. Mathematics: Elective Compulsory		
	Interdisciplinary Mathematics: Specialisation	n Computational Methods in Biomedical Imaging:	Compulsory	
	Mechatronics: Technical Complementary Co	urse: Elective Compulsory		
	Mechatronics: Specialisation System Design	: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Syst	ems and Robotics: Elective Compulsory		
	Technomathematics: Specialisation I. Mathe	matics: Elective Compulsory		
	Theoretical Mechanical Engineering: Technic	cal Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Special	isation Robotics and Computer Science: Elective	Compulsory	
	Process Engineering: Specialisation Process	Engineering: Elective Compulsory		

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

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

Module M0781: EMC I	I: Signal Integrity and Power Su	pply of Electronic Systems		
Courses				
	Supply of Electronic Systems (L0770) Supply of Electronic Systems (L0771)	Typ Lecture Recitation Section (small)	Hrs/wk 3 1	CP 4 1
EMC II: Signal Integrity and Power S	Supply of Electronic Systems (L0774)	Practical Course	1	1
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of electrical engineering			
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence Knowledge	Students are able to explain the fundament electronic systems. They are able to relate signile. their electromagnetic compatibility. They are packages and interconnects. They are able to issues. They are capable of giving an overview integrity in electrical engineering practice.	nal and power integrity to the context of are capable of explaining the basic behav o propose and describe problem solving	interference-free des ior of signals and por strategies for signal	sign of such systems wer supply in typical and power integrity
Skills	Students are able to apply a series of modeling methods for characterization of electromagnetic field behavior in packages and interconnect structure of electronic systems. They are able to determine the most important effects that these models are predicting in terms of signal and power integrity. They can classify these effects and they can quantitatively analyze them. They are capable of deriving problem solving strategies from these predictions and they can adapt them to applications in electrical engineering practice. The can evaluate their problem solving strategies against each other.			
Personal Competence Social Competence	Students are able to work together on subjec English (e.g. during CAD exercises).	t related tasks in small groups. They are	able to present their	results effectively ir
Autonomy	Students are capable to gather necessary information from the references provided and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, communications, and semiconductor circuit design). They can communicate problems and solutions in the field of signal integrity and power supply of interconnect and packages in English.			
Workload in Hours	Independent Study Time 110, Study Time in Le	ecture 70		
Credit points	, , ,			
Course achievement	Compulsory Bonus Form	Description		
Francischter	Yes None Presentation			
Examination Examination duration and scale				
Assignment for the Following Curricula	Electrical Engineering: Specialisation Microwav Electrical Engineering: Specialisation Nanoelec Mechatronics: Technical Complementary Cours Microelectronics and Microsystems: Specialisal	tronics and Microsystems Technology: Elective Compulsory	ctive Compulsory	ive Compulsory

Course L0770: EMC II: Signal	Integrity and Power Supply of Electronic Systems
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	- The role of packages and interconnects in electronic systems
	- Components of packages and interconnects in electronic systems
	- Main goals and concepts of signal and power integrity of electronic systems
	- Repeat of relevant concepts from the theory electromagnetic fields
	- Properties of digital signals and systems
	- Design and characterization of signal integrity
	- Design and characterization of power supply
	- Techniques and devices for measurements in time- and frequency-domain
	- CAD tools for electrical analysis and design of packages and interconnects
	- Connection to overall electromagnetic compatibility of electronic systems
Literature	- J. Franz, "EMV: Störungssicherer Aufbau elektronischer Schaltungen", Springer (2012)
	- R. Tummala, "Fundamentals of Microsystems Packaging", McGraw-Hill (2001)
	- S. Ramo, J. Whinnery, T. Van Duzer, "Fields and Waves in Communication Electronics", Wiley (1994)
	- S. Thierauf, "Understanding Signal Integrity", Artech House (2010)
	- M. Swaminathan, A. Engin, "Power Integrity Modeling and Design for Semiconductors and Systems", Prentice-Hall (2007)

Course L0771: EMC II: Signal Integrity and Power Supply of Electronic Systems		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0774: EMC II: Signal	Integrity and Power Supply of Electronic Systems
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
-	Prof. Christian Schuster
Language	
Cycle	
Content	- The role of packages and interconnects in electronic systems
	- Components of packages and interconnects in electronic systems
	- Main goals and concepts of signal and power integrity of electronic systems
	- Repeat of relevant concepts from the theory electromagnetic fields
	- Properties of digital signals and systems
	- Design and characterization of signal integrity
	- Design and characterization of power supply
	- Techniques and devices for measurements in time- and frequency-domain
	- CAD tools for electrical analysis and design of packages and interconnects
	- Connection to overall electromagnetic compatibility of electronic systems
Literature	- J. Franz, "EMV: Störungssicherer Aufbau elektronischer Schaltungen", Springer (2012)
	- R. Tummala, "Fundamentals of Microsystems Packaging", McGraw-Hill (2001)
	- S. Ramo, J. Whinnery, T. Van Duzer, "Fields and Waves in Communication Electronics", Wiley (1994)
	- S. Thierauf, "Understanding Signal Integrity", Artech House (2010)
	- M. Swaminathan, A. Engin, "Power Integrity Modeling and Design for Semiconductors and Systems", Prentice-Hall (2007)

Module M1150: Conti	nuum Mechanics			
Courses				
Title	Typ Hrs/wk CP			
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1	534)	Recitation Section (small) 2 3		
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e.g., ir	n the module Mechanics II (forces and	d moments, stres	ss, linear strain, free-
Knowledge	body principle, linear-elastic constitutive laws, strain end	ergy).		
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to c	alculate the mechanical behavior of n	naterials.	
Skills	The students can set up balance laws and apply basics	s of deformation theory to specific as	nects both in a	nnlied contexts as in
JKIII3	research contexts.	or deformation theory to specific as	pects, both in a	pplied contexts as in
	researen euneaksi			
Personal Competence				
Social Competence	The students are able to develop solutions, to present them to specialists in written form and to develop ideas further.			
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve			
	problems in the area of continuum mechanics and acqui	re the knowledge required to this end	l.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Com	npulsory	·	
Following Curricula	Mechanical Engineering and Management: Specialisation	n Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Electiv	e Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs	-	Compulsory	
	Biomedical Engineering: Specialisation Implants and Engineering			
	Biomedical Engineering: Specialisation Medical Technolo			
	Biomedical Engineering: Specialisation Management and		mpulsory	
	Product Development, Materials and Production: Core qu	, ,		
	Theoretical Mechanical Engineering: Technical Complem			
	Theoretical Mechanical Engineering: Core qualification: I	Elective Compulsory		

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

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

Module M1336: Soft (Computing - Introduction to N	Machine Learning		
Courses				
Title		Тур	Hrs/wk	СР
Soft Computing - Introduction to Ma	achine Learning (L1869)	Lecture	4	6
Module Responsible	Prof. Karl-Heinz Zimmermann			
Admission Requirements	None			
Recommended Previous	Bachelor in Computer Science.			
Knowledge	Basics in higher mathematics are inevitable, like calculus, linear algebra, graph theory, and optimization.			
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models,			
	phylogenetic tree models, classical regression and clustering methods, neural networks, and fuzzy controllers.			
Skills	Students can apply the relevant algorithms and determine their complexity, and they can make use of the statistics language R.			
Personal Competence				
Social Competence	Students are able to solve specific problems alone or in a group and to present the results accordingly.			
Autonomy	Students are able to acquire new knowledge from newer literature and to associate the acquired knowledge to other fields.			
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	25 min			
scale				
Assignment for the	Mechatronics: Technical Complementary (Course: Elective Compulsory		
Following Curricula				

•	ng - Introduction to Machine Learning
Тур	Lecture
Hrs/wk	4
СР	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Karl-Heinz Zimmermann, Dr. Mehwish Saleemi
Language	DE/EN
Cycle	WiSe
Content	Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models,
	phylogenetic tree models, neural networks, and fuzzy controllers. In particular, inference and learning in belief networks are
	important topics that the students should be able to master.
	Students can apply the relevant algorithms and determine their complexity, and they can make use of the statistics language R.
Literature	1. David Barber, Bayes Reasoning and Machine Learning, Cambridge Univ. Press, Cambridge, 2012.
	2. Volker Claus, Stochastische Automaten, Teubner, Stuttgart, 1971.
	3. Ernst Klement, Radko Mesiar, Endre Pap, Triangular Norms, Kluwer, Dordrecht, 2000.
	4. Timo Koski, John M. Noble, Bayesian Networks, Wiley, New York, 2009.
	5. Dimitris Margaritis, Learning Bayesian Network Model Structure from Data, PhD thesis, Carnegie Mellon
	University, Pittsburgh, 2003.
	6. Hidetoshi Nishimori, Statistical Physics of Spin Glasses and Information Processing, Oxford Univ. Press,
	London, 2001.
	7. James R. Norris, Markov Chains, Cambridge Univ. Press, Cambridge, 1996.
	8. Maria Rizzo, Statistical Computing with R, Chapman & Hall/CRC, Boca Raton, 2008.
	9. Peter Sprites, Clark Glymour, Richard Scheines, Causation, Prediction, and Search, Springer, New York,
	1993.
	10. Raul Royas, Neural Networks, Springer, Berlin, 1996.
	11. Lior Pachter, Bernd Sturmfels, Algebraic Statistics for Computational Biology, Cambridge Univ. Press,
	Cambridge, 2005.
	12. David A. Sprecher, From Algebra to Computational Algorithms, Docent Press, Boston, 2017.
	13. Karl-Heinz Zimmermann, Algebraic Statistics, TubDok, Hamburg, 2016.

Module M1552: Matho	ematics of Neural Networks			
Courses				
Title		Тур	Hrs/wk	СР
Mathematics of Neural Networks (L	.2322)	Lecture	2	3
Mathematics of Neural Networks (L	2323)	Recitation Section (small)	2	3
Module Responsible	Dr. Jens-Peter Zemke			
Admission Requirements	None			
Recommended Previous	Mathematics I-III			
Knowledge	Numerical Mathematics 1/ Numerics			
	3. Programming skills, preferably in Python			
	3 3 11 , , ,			
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge	Students are able to name, state and classify state-of-t	he-art neural networks and their cor	responding mathe	ematical basics. They
	can assess the difficulties of different neural networks.			
	Students are able to implement, understand, and, tailor	ed to the field of application, apply n	eural networks.	
Personal Competence				
Social Competence	Students can			
	develop and document joint solutions in small tea	ams;		
	form groups to further develop the ideas and training	nsfer them to other areas of applicable	ility;	
	 form a team to develop, build, and advance a so 	tware library.		
Autonomy	Students are able to			
	correctly assess the time and effort of self-define	d work:		
	assess whether the supporting theoretical and pr		ndividually or in a	team;
	define test problems for testing and expanding tl		, , , , , ,	,
	assess their individual progess and, if necessary,	to ask questions and seek help.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	25 min			
scale				
Assignment for the	Computer Science: Specialisation III. Mathematics: Elec	tive Compulsory		
Following Curricula	Computational Science and Engineering: Specialisation	III. Mathematics: Elective Compulsory	/	
	Mechatronics: Specialisation Intelligent Systems and Ro	botics: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective	ve Compulsory		
	Technomathematics: Specialisation I. Mathematics: Elec			
	Theoretical Mechanical Engineering: Specialisation Rob	otics and Computer Science: Elective	Compulsory	

Course L2322: Mathematics	of Neural Networks
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	 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: Mathematics of Neural Networks	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Thesis

Module M-002: Master Thesis		
Courses		
itle	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		
Momeage	The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialize	
	 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.	
61.11	The childrate are able.	
Skills	The students are able:	
	To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question	
	 To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/incompletely defined problems in a solution-oriented way. 	
	To develop new scientific findings in their subject area and subject them to a critical assessment.	
Personal Competence Social Competence	Students can	
Social Competence	Students Can	
	Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structur	
	 way. Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addresse 	
	while upholding their own assessments and viewpoints convincingly.	
Autonomy	Students are able:	
	To structure a project of their own in work packages and to work them off accordingly.	
	To work their way in depth into a largely unknown subject and to access the information required for them to do so.	
	To apply the techniques of scientific work comprehensively in research of their own.	
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0	
Credit points	30	
Course achievement		
Examination		
Examination duration and scale	According to General Regulations	
Assignment for the	Civil Engineering: Thesis: Compulsory	
Following Curricula		
	Chemical and Bioprocess Engineering: Thesis: Compulsory	
	Computer Science: Thesis: Compulsory	
	Electrical Engineering: Thesis: Compulsory Energy and Environmental Engineering: Thesis: Compulsory	
	Energy Systems: Thesis: Compulsory	
	Environmental Engineering: Thesis: Compulsory	
	Aircraft Systems Engineering: Thesis: Compulsory	
	Global Innovation Management: Thesis: Compulsory	
	Computational Science and Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory	
	Interdisciplinary Mathematics: Thesis: Compulsory	
	International Management and Engineering: Thesis: Compulsory	
	Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory	
	Logistics, Infrastructure and Mobility: Thesis: Compulsory Materials Science: Thesis: Compulsory	
	Mechanical Engineering and Management: Thesis: Compulsory	
	Mechatronics: Thesis: Compulsory	
	Biomedical Engineering: Thesis: Compulsory	
	Microelectronics and Microsystems: Thesis: Compulsory	
	Product Development, Materials and Production: Thesis: Compulsory Renewable Energies: Thesis: Compulsory	
	Tremendate Energies. Trests. Computatory	

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	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