

Module Manual

Master of Science (M.Sc.)

Mechatronics

Cohort: Winter Term 2020

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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	 Students are able to find their way around selected special areas of management within the scope of business management. Students are able to explain basic theories, categories, and models in selected special areas of business management. Students are able to interrelate technical and management knowledge.
Skills	 Students are able to apply basic methods in selected areas of business management. Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.
Personal Competence	
Social Competence	Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems
Autonomy	Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.
Workload in Hours	Depends on choice of courses
Credit points	6

Courses

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

Module M0524: Non-technical Courses for Master			
Module Responsible	Dagmar Richter		
Admission Requirements	None		
Recommended Previous	None		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
5 6 1 10 1			

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
- 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
- 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)

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 M0563: Robot	tics			
Courses				
Title		Тур	Hrs/wk	СР
Robotics: Modelling and Control (LC	168)	Lecture	3	3
Robotics: Modelling and Control (L1	305)	Recitation Section (large)	2	3
Module Responsible	Prof. Uwe Weltin			
Admission Requirements	None			
Recommended Previous	Fundamentals of electrical engineering			
Knowledge	Broad knowledge of mechanics			
	broad knowledge of mechanics			
	Fundamentals of control theory			
Educational Objectives	After taking part successfully, students have reached the	ne following learning results		
Professional Competence				
Knowledge	Students are able to describe fundamental properties of	f robots and solution approaches for	multiple problems	in robotics.
Skills	Students are able to derive and solve equations of mot	on for various manipulators.		
	Students can generate trajectories in various coordinat	e 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.			
	with instructor assistance, students are able to evaluat	e their own knowledge level and deli	ne a further cours	e or study.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Aircraft Systems Engineering: Specialisation Aircraft Sy	stems: Elective Compulsory		
Following Curricula	International Management and Engineering: Specialisat	ion II. Mechatronics: Elective Compu	lsory	
	International Management and Engineering: Specialisat	·	duction: Elective C	compulsory
	Mechanical Engineering and Management: Core Qualific	cation: Compulsory		
	Mechatronics: Core Qualification: Compulsory	liantian Dundont Davidson	Camanulaan	
	Product Development, Materials and Production: Special	·		
	Product Development, Materials and Production: Special	·	-	
	Product Development, Materials and Production: Special Theoretical Mechanical Engineering: Technical Completed	·	•	
	Theoretical Mechanical Engineering: Technical Completed Theoretical Mechanical Engineering: Specialisation Proceedings			,
	Theoretical Mechanical Engineering: Specialisation Rob	•		
		Table Sompator Science: Elective	- 5p a501 y	

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

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

Courses				
Γitle		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)	Draf Otto von Ectorff	Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements Recommended Previous	None Machanics L (Statics, Machanics of Materials) and Machan	ice II (Hydrostatics Vinomatics Dyn	amics)	
Knowledge		ics ii (Hydrostatics, Killelliatics, Dyli	arriics)	
Knowicuge	Fractionales I, II, III (III particular afficiential equations)			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge regarding overview of the theoretical and methodical basis of the m		ent method and	are able to give
	overview of the theoretical and methodical basis of the m	curiou.		
Skills	The students are capable to handle engineering problem		ments, assemblin	g the correspondi
	system matrices, and solving the resulting system of equa	ations.		
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 computational problems and o	levelop own finit	e element routin
,	The students are able to independently solve challenging computational problems and develop own finite element routing Problems can be identified and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Descrip	tion		
	No 20 % Midterm			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the				
Following Curricula		- Flasting Commuter		
	Aircraft Systems Engineering: Specialisation Aircraft Syste Aircraft Systems Engineering: Specialisation Aircraft Syste			
	Aircraft Systems Engineering: Specialisation Air Transport			
	Aircraft Systems Engineering: Specialisation Air Transport			
	International Management and Engineering: Specialisation			
	International Management and Engineering: Specialisation	n II. Mechatronics: Elective Compuls	ory	
	International Management and Engineering: Specialisation	n II. Product Development and Produ	iction: Elective Co	ompulsory
	International Management and Engineering: Specialisation	n II. Product Development and Produ	iction: Elective Co	ompulsory
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Implants and Endo			
	Biomedical Engineering: Specialisation Management and		. ,	
	Biomedical Engineering: Specialisation Medical Technolog	•	-	
	Biomedical Engineering: Specialisation Artificial Organs at Product Development, Materials and Production: Core Qua	-	Lornpulsory	
	Technomathematics: Specialisation III. Engineering Science			
	precialization action and a specialization in Linguisting Stitling	.c. Liccure Compulation y		
	Technomathematics: Specialisation III. Engineering Science			

Course L0291: 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	ol Systems Theory and Design				
Courses					
Title		Tun	Hro hule	СР	
Control Systems Theory and Design	(1.0656)	Typ Lecture	Hrs/wk 2	4	
Control Systems Theory and Design		Recitation Section (small)	2	2	
Admission Requirements	None				
-					
Recommended Previous	Introduction to Control Systems				
Knowledge	After helding and account the students have a second	Laboratoria de la contra de consta			
Educational Objectives	After taking part successfully, students have reached	t the following learning results			
Professional Competence					
Knowledge	Students can explain how linear dynamic sys	tems are represented as state space mo	dels; they can	interpret the system	
	response to initial states or external excitation	as trajectories in state space			
	 They can explain the system properties contr 	ollability and observability, and their rela	tionship to state	e feedback and state	
	estimation, respectively				
	 They can explain the significance of a minima 	realisation			
	They can explain observer-based state feedba	ck and how it can be used to achieve trac	king and disturb	ance rejection	
	 They can extend all of the above to multi-input 	t multi-output systems			
	They can explain the z-transform and its relation	·			
	They can explain state space models and tran	•			
	They can explain the experimental identificati	on of ARX models of dynamic systems, an	d how the ident	ification problem can	
	be solved by solving a normal equation				
	They can explain how a state space model can	be constructed from a discrete-time imp	ulse response		
Skills					
	Students can transform transfer function mod				
	They can assess controllability and observabil				
	They can design LQG controllers for multivariable plants				
	They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriate				
	for a given sampling rate	d atata anaga mandala af di mamia ayatama	fuana avaasinaan	tal data	
	They can identify transfer function models and state space models of dynamic systems from experimental data They can sarry out all these tasks using standard coffware tools (Matlah Central Toolhov, System Identification Toolhov,				
	 They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox, Simulink) 				
	Simulation				
Personal Competence					
Social Competence	Students can work in small groups on specific proble	ms to arrive at joint solutions.			
Autonomy	Students can obtain information from provided sou	rces (lecture notes, software documenta	tion, experimer	it guides) and use it	
	Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems.				
	They can assess their knowledge in weekly on-line tests and thereby control their learning progress.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56			
Credit points					
•					
Course achievement	None				
	Written exam				
Examination duration and	120 min				
scale					
-	Electrical Engineering: Core Qualification: Compulsor	•			
Following Curricula		•			
	Aircraft Systems Engineering: Specialisation Aircraft				
	Aircraft Systems Engineering: Specialisation Avionic		lcon/		
	Computational Science and Engineering: Specialisati		-		
	International Management and Engineering: Speciali				
	International Management and Engineering: Specialis	·	ıy		
	Mechanical Engineering and Management: Specialisa	nion Mechanomics: Elective Compulsory			
	Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Orga	ns and Regenerative Medicine: Elective C	ampulson/		
	Biomedical Engineering: Specialisation Artificial Organisation Implants and	•	ompuisory		
	Biomedical Engineering: Specialisation Implants and				
	Biomedical Engineering: Specialisation Medical Technical Engineering: Specialisation Management		npulsorv		
	Product Development, Materials and Production: Cor.		,,		
	Theoretical Mechanical Engineering: Core Qualification	, ,			
	5				

Tvn	Lecture	
Hrs/wk		
	4	
	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 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: Desig	n and Implementation of Softwar	re Systems		
Courses				
Title		Тур	Hrs/wk	СР
Design and Implementation of Soft Design and Implementation of Soft		Lecture Practical Course	2	3
	Prof. Bernd-Christian Renner	Tractical Course		
Admission Requirements				
•	- Imperativ programming languages (C, Pascal, F	Fortran or similar)		
Knowledge	- Simple data types (integer, double, char, boolean), arrays, if-then-else, for, while, procedure and function calls			
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge	Students are able to describe mechatronic syste	ms and define requirements.		
Skills	Students are able to design and implement mechatronic systems. They are able to argue the combination of Hard- and Softwar and the interfaces.			Hard- and Software
Personal Competence				
-	Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities and define task within the team.			nd define task within
Autonomy	Students are able to solve individually exercises related to this lecture with instructional direction. Students are able to plan, execute and summarize a mechatronic experiment.			
Workload in Hours	Independent Study Time 124, Study Time in Lec	ture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
•	Mechatronics: Core Qualification: Compulsory			
Following Curricula	Theoretical Mechanical Engineering: Technical C		•	
	Theoretical Mechanical Engineering: Specialisation	on Robotics and Computer Science: Elect	tive Compulsory	

Course L1657: Design and In	nplementation of Software Systems
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bernd-Christian Renner
Language	EN
Cycle	WiSe
	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 Implementation of Software Systems		
Тур	Practical Course	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Bernd-Christian Renner	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module 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	following learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibra	ion Theory and develop them furt	her.	
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 tasks	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: Specialisation	n II. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management: Specialisation	Mechatronics: Elective Compulso	ry	
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs a	nd Regenerative Medicine: Electiv	e Compulsory	
	Biomedical Engineering: Specialisation Implants and End			
	Biomedical Engineering: Specialisation Medical Technology	•		
	Biomedical Engineering: Specialisation Management and		Compulsory	
	Product Development, Materials and Production: Core Qu			
	Naval Architecture and Ocean Engineering: Core Qualifica			
	Theoretical Mechanical Engineering: Technical Compleme		У	
	Theoretical Mechanical Engineering: Core Qualification: E	lective Compulsory		

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

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: Appro	oximation 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, inte 		ular values	
Educational Objectives	After taking part successfully, students have reached t	the following learning results		
Professional Competence				
Knowledge	Students are able to			
	sketch and interrelate basic concepts of function name and understand concrete approximation r name and explain basic stability theorems, discuss spectral quantities, conditions numbers	methods,		
Skills	Students are able to			
	 apply basic results from functional analysis, apply approximation methods, apply stability theorems, compute spectral quantities, apply regularisation methods. 			
Personal Competence Social Competence	Students are able to solve specific problems in groups	and to present their results appropriate	ely (e.g. as a sem	iinar presentation).
Autonomy	 Students are capable of checking their underst precisely and know where to get help in solving Students have developed sufficient persistence problems. 	them.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points	6			
Course achievement	Compulsory Bonus Form Des Yes None Presentation	cription		
Examination	Oral exam			
Examination duration and scale	20 min			
Assignment for the	Electrical Engineering: Specialisation Control and Powe	er Systems Engineering: Elective Comp	ulsory	
Following Curricula	Mathematical Modelling in Engineering: Theory, Nume Mechatronics: Specialisation Intelligent Systems and R Technomathematics: Specialisation I. Mathematics: Ele	obotics: Elective Compulsory	erics (TUHH): Ele	ctive Compulsory
	Theoretical Mechanical Engineering: Technical Comple			
	Theoretical Mechanical Engineering: Specialisation Rol	potics and Computer Science: Elective (Compulsory	

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

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

Module 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			
	2. Inglineering viceliaries			
Educational Objectives	After taking part successfully, students have reached t	he following learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and conc	epts in Nonlinear Dynamics and to	develop and resea	rch new terms and
	concepts.			
Skills	Students are able to apply existing methods and proce	sures 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 individually and to identify and follow up novel research tasks by themselves.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	5		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Aircraft Systems Engineering: Specialisation Aircraft Sy	stems: Elective Compulsory		
Following Curricula	International Management and Engineering: Specialisa	tion II. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management: Specialisation	on Mechatronics: Elective Compulso	ry	
	Mechatronics: Specialisation System Design: Elective C	ompulsory		
	Mechatronics: Specialisation Intelligent Systems and Re	obotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective	e Compulsory	
	Biomedical Engineering: Specialisation Implants and Er			
	Biomedical Engineering: Specialisation Medical Techno	*		
	Biomedical Engineering: Specialisation Management ar		Compulsory	
	Product Development, Materials and Production: Core (
	Theoretical Mechanical Engineering: Technical Comple	, ,	ТУ	
	Theoretical Mechanical Engineering: Core Qualification	: Elective 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 M0840: Optin				
Courses				
Title		Тур	Hrs/wk	СР
Optimal and Robust Control (L0658 Optimal and Robust Control (L0659		Lecture Recitation Section (small)	2	3
Module Responsible		recitation section (smail)		
Admission Requirements	None			
Recommended Previous				
Knowledge	Classical control (frequency response, root lo	cus)		
	State space methods Linear algebra, singular value decomposition			
	 Linear algebra, singular value decomposition 			
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
Knowledge	Students can explain the significance of the r	natrix Riccati equation for the solution of	LO problems.	
	They can explain the duality between optima			
	They can explain how the H2 and H-infinity notes.			traints.
	 They can explain how an LQG design problem 	can be formulated as special case of an	H2 design proble	m.
	They can explain how model uncertainty can	·		-
	They can explain how - based on the small of the sma	gain theorem - a robust controller can gu	arantee stability	and performance for
	an uncertain plant.They understand how analysis and synthesis	conditions on feedback loops can be repr	esented as linear	matrix inequalities
	They understand now undrysis and synthesis	conditions on recapack loops can be repr	eserred as inical	matrix mequanties
Skills	 Students are capable of designing and tuning 	LOG controllers for multivariable plant m	odels.	
	They are capable of representing a H2 or H-ii			nd of using standa
	software tools for solving it.			
	They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loop			
	sensitivity functions, and of carrying out a mixed-sensitivity design.			
	They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective They are capable of construction of the capable of th			
	robust controller.	I synthosis conditions as linear matrix inc	auglities (LMI)	nd of using standay
	 They are capable of formulating analysis and LMI-solvers for solving them. 	i synthesis conditions as linear matrix me	equalities (LMI), a	na or using standar
	They can carry out all of the above using star	ndard software tools (Matlab robust contro	ol toolbox).	
	, , ,			
Personal Competence	Charles to a second in small annual and a second and a second			
	Students can work in small groups on specific proble		oftware decume	ntation) and use it t
Autonomy	Students are able to find required information in solve given problems.	urces provided (lecture flotes, literature, s	software docume	illation) and use it i
	Solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture	2 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Control and Po	wer Systems Engineering: Elective Comp	ulsorv	
-	Energy Systems: Core Qualification: Elective Compu		,	
	Aircraft Systems Engineering: Specialisation Aircraft	Systems: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems and	Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Electiv			
	Biomedical Engineering: Specialisation Artificial Org		Compulsory	
	Biomedical Engineering: Specialisation Implants and		nulcony	
	Biomedical Engineering: Specialisation Medical Tech Biomedical Engineering: Specialisation Management	**		
	Product Development, Materials and Production: Specialisation			
	Product Development, Materials and Production: Spo			
	Product Development, Materials and Production: Spe			
	Theoretical Mechanical Engineering: Technical Com	plementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core Qualificat	ion: Elective Compulsory		

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

Course L0659: Optimal and F	ourse 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 M0714: Nume	erical Treatment of Ordinary Differ	ential 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 Ingenieurstudierend	e (deutsch oder englisch) oder Analysis & Li	neare Algebra I	+ II sowie Analysis III
Knowledge	für Technomathematiker Basic MATLAB knowledge			,
Educational Objectives	After taking part successfully, students have read	ned the following learning results		
Professional Competence		ica and rono ming rearrang results		
•	Students are able to			
Mowicage	Students are able to			
	list numerical methods for the solution of o			
	repeat convergence statements for the t	reated numerical methods (including the	prerequisites tie	ed to the underlying
	problem),	aution of a model of		
	explain aspects regarding the practical exe		numorical algori	thms officiently and
	 select the appropriate numerical method for concrete problems, implement the numerical algorithms efficiently and interpret the numerical results 			
	·			
Skills	Students are able to			
	• implement (MATLAB), apply and compare numerical methods for the solution of ordinary differential equations,			
	to justify the convergence behaviour of numerical methods with respect to the posed problem and selected algorithm,			
	• for a given problem, develop a suitable solution approach, if necessary by the composition of several algorithms, to execute			
	this approach and to critically evaluate the results.			
Personal Competence				
Social Competence	Students are able to			
	work together in heterogeneously compose	ed teams (i.e., teams from different study pr	ograms and bac	kground knowledge)
	explain theoretical foundations and support	each other with practical aspects regarding	the implementa	ation of algorithms.
4	Churchamba and as a bla			
Autonomy	Students are capable			
	to assess whether the supporting theoretics	al and practical excercises are better solved	individually or in	n a team,
	to assess their individual progress and, if no	ecessary, to ask questions and seek help.		
Workload in Hours	Independent Study Time 124, Study Time in Lectu	re 56		
Credit points				
Course achievement	None			
	Written exam			
Examination duration and				
scale				
Assignment for the	Bioprocess Engineering: Specialisation A - Genera	Bioprocess Engineering: Elective Compulso	ry	
Following Curricula			-	
	Chemical and Bioprocess Engineering: Specialisat	on General Process Engineering: Elective Co	ompulsory	
	Computer Science: Specialisation III. Mathematics	: Elective Compulsory		
	Electrical Engineering: Specialisation Control and	Power Systems Engineering: Elective Compu	ilsory	
	Energy Systems: Core Qualification: Elective Com	pulsory		
	Aircraft Systems Engineering: Specialisation Aircra	, ,		
	Mathematical Modelling in Engineering: Theory, N	··	erics (TUHH): Co	mpulsory
	Mechatronics: Specialisation Intelligent Systems a			
	Technomathematics: Specialisation I. Mathematic			
	Theoretical Mechanical Engineering: Core Qualific			
	Process Engineering: Specialisation Chemical Process Engineering: Specialisation Process Engineering:			
	Process Engineering: Specialisation Process Engin	eering. Elective Compulsory		

Course L0576: Numerical Tre	eatment 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 Tre	ourse 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		

Module M1156: Syste	ems Engineering			
Courses				
Title		Тур	Hrs/wk	СР
Systems Engineering (L1547)		Lecture	3	4
Systems Engineering (L1548)	T	Recitation Section (large)	1	2
Module Responsible				
Admission Requirements	None			
Recommended Previous	1			
Knowledge				
	• Mechanics			
	• Thermodynamics			
	Electrical Engineering Control Systems			
	Control Systems			
	Previous knowledge in:			
	Aircraft Cabin Systems			
Educational Objectives	After taking part successfully, students have reached the following	ng learning results		
Professional Competence				
Knowledge	Students are able to:			
	understand systems engineering process models, methods and		f complex System	S
	describe innovation processes and the need for technology Mar	-		
	explain the aircraft development process and the process of tyl			
	explain the system development process, including requirement			
	identify environmental conditions and test procedures for airbo value the methodology of requirements become agricultural of the procedure of the proc			(MDDE)
	value the methodology of requirements-based engineering (RB	E) and model-based requirer	nents engineering	(MBKE)
Skills	Students are able to:			
	plan the process for the development of complex Systems			
	organize the development phases and development Tasks			
	assign required business activities and technical Tasks			
	apply systems engineering methods and tools			
Personal Competence				
•	Students are able to:			
30ciai competence	understand their responsibilities within a development team an	nd integrate themselves with	their role in the o	verall process
	anderstand their responsibilities within a development team an	ia integrate trieffiseives with	their role in the o	verali process
Autonomy	Students are able to:			
	• interact and communicate in a development team which has di	stributed tasks		
	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
	Written exam			
Examination duration and	120 Minutes			
scale				
•	Aircraft Systems Engineering: Core Qualification: Compulsory			
Following Curricula			-	
	International Management and Engineering: Specialisation II. Pro	·	ıctıon: Elective Co	mpulsory
	Mechatronics: Specialisation System Design: Elective Compulsory			
	Mechatronics: Specialisation Intelligent Systems and Robotics: El			
	Product Development, Materials and Production: Specialisation Production:			
	Product Development, Materials and Production: Specialisation Production:			
	Product Development, Materials and Production: Specialisation M		/	
	Theoretical Mechanical Engineering: Technical Complementary C	, ,	mm. dann.	
	Theoretical Mechanical Engineering: Specialisation Aircraft Syste	ms Engineering: Elective Cor	приіѕогу	

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 Engi	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	Prof. Uwe Weltin		
Admission Requirements	None		
Recommended Previous	See selected module according to FSPO		
Knowledge			
	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	see selected module according to FSPO		
Skills	see selected module according to FSPO		
Personal Competence			
•	see selected module according to FSPO		
Social Competence	see selected module according to rspo		
Autonom	see selected module according to FSPO		
Autonomy	see selected module according to FSPO		
Workload in Hours	Depends on choice of courses		
Credit points			
	Mechatronics: Specialisation System Design: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory		

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
Development Management for Med	chatronics (L1512)	Lecture	2	3
atigue & Damage Tolerance (L031	10)	Lecture	2	3
ndustry 4.0 for engineers (L2012)		Lecture	2	3
licrocontroller Circuits: Implement	tation in Hardware and Software (L0087)	Seminar	2	2
Nicrosystems 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
eedback Control in Medical Techn	ology (L0664)	Lecture	2	3
Six Sigma (L1130)		Lecture	2	3
Applied Dynamics (L1630)		Lecture	2	3
Reliability in Engineering Dynamics	s (L0176)	Lecture	2	2
Reliability in Engineering Dynamics	s (L1303)	Recitation Section (small)	1	2
Module Responsible	Prof. Uwe Weltin			
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 different special fields or applicat areas of mechatronics Students are qualified to connect different special fields with each other 			
Skills	 Students can 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 develop own solution approaches 			
Personal Competence	News			
Social Competence	None			
Autonomy	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		
	Mechatronics: Specialisation Intelligent Systems and	Robotics: Flective 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

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	Dr. Johannes Nicolas Gebhardt, Dr. Daniel Steffen
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: Microcontrolle	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	
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, 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; spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biose
	 MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration) Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding
Literature	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009 T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

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	- Färber: "Prozeßrechentechnik", Springer-Verlag 1994
	- Kiencke, Kronmüller: "Meßtechnik", Springer Verlag Berlin Heidelberg, 1995
	- A. Ambardar: "Analog and Digital Signal Processing" (1), PWS Publishing Company, 1995, NTC 339
	- A. Papoulis: "Signal Analysis" (1), McGraw-Hill, 1987, NTC 312 (LB)
	- M. Schwartz: "Information Transmission, Modulation and Noise" (3,4), McGraw-Hill, 1980, 2402095
	- S. Haykin: "Communication Systems" (1,3), Wiley&Sons, 1983, 2419072
	- H. Sheingold: "Analog-Digital Conversion Handbook" (5), Prentice-Hall, 1986, 2440072
	- J. Fraden: "AIP Handbook of Modern Sensors" (5,6), American Institute of Physics, 1993, MTB 346

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

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

Course L1130: Six Sigma	
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 Minuten
scale	
Lecturer	Prof. Claus Emmelmann
Language	DE
Cycle	WiSe
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC
Literature	Pfeifer, T.: Qualitätsmanagement: Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität: Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008

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	 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.	

Course L0176: Reliability in Engineering Dynamics					
	Lecture				
Hrs/wk					
СР					
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28				
Examination Form	Klausur				
Examination duration and	90 min.				
scale					
Lecturer	Prof. Uwe Weltin				
Language	EN				
Cycle	SoSe SoSe				
	Method for calculation and testing of reliability of dynamic machine systems Modeling System identification Simulation Processing of measurement data Damage accumulation Test planning and execution				
Literature	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4 Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737 Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936. VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412				

Course L1303: Reliability in Engineering Dynamics			
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Examination Form	Klausur		
Examination duration and	90 min		
scale			
Lecturer	Prof. Uwe Weltin		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M1224: Selected Topics of Mechatronics (Alternative B: 6 LP)						
Courses						
Title	Т	ур	Hrs/wk	СР		
Applied Automation (L1592)		roject-/problem-based Learning	3	3		
Development Management for Mechatronics (L1512)		ecture	2	3		
Fatigue & Damage Tolerance (L0310)		ecture	2	3		
Industry 4.0 for engineers (L2012)		ecture	2	3		
Microcontroller Circuits: Implementation in Hardware and Software (L0087)		eminar	2	2		
Microsystems Technology (L0724)		ecture	2	4		
Model-Based Systems Engineering (MBSE) with SysML/UML (L1551)		roject-/problem-based Learning	3	3		
Process Measurement Engineering (L1077)		ecture	2	3		
Process Measurement Engineering (L1083)		ecitation Section (large)	1	1		
Feedback Control in Medical Technology (L0664)		ecture	2	3		
Six Sigma (L1130)		ecture	2	3		
Applied Dynamics (L1630)		ecture	2	3		
Reliability in Engineering Dynamics (L0176)		ecture	2	2		
Reliability in Engineering Dynamics (L1303) Recitation 5		ecitation Section (small)	1	2		
Module Responsible	Prof. Uwe Weltin					
Admission Requirements	None					
Recommended Previous	None					
Knowledge						
Educational Objectives	After taking part successfully, students have reached the following learning results					
Professional Competence						
Knowledge						
_	 Students are able to express their extended knowledge and discuss the connection of different special fields or application 					
	areas of mechatronics					
	Students are qualified to connect different special fields with each other					
Skills						
SKIIIS	Students can apply specialized solution strategies and new scientific methods in selected areas					
	Students are able to transfer learned skills to new and unknown	own problems and can develop	own solution a	proaches		
Personal Competence						
Social Competence	None					
Autonomy						
	Students are able to develop their knowledge and skills by autonomous election of courses.					
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					

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 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	Dr. Johannes Nicolas Gebhardt, Dr. Daniel Steffen	
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: Microcontrolle	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	

	Lactura
Тур	Lecture
СР	4
Examination Form	Mündliche Prüfung
xamination duration and scale	30 min
	Prof. Hoc Khiem Trieu
Language	
Cycle	
Content	MIDE
	 Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generatilithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; C techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etchina anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop technique 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 measur Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermop modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemomet mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer) Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sens piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rasensor: operating principle and fabrication process; sensor spinning current Hall sensor and magneto-transistor; magnetoresist sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gensors sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosens Clark electrode, enzyme electrode, DNA chip) Micro Actuators, Microfluidics and TAS (drives: th
	 micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-or chip, microanalytics) MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery systestimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implor spinal cord regeneration) Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelli multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-relationship) System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bond 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

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	
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:	
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 L1130: Six Sigma	
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 Minuten
scale	
Lecturer	Prof. Claus Emmelmann
Language	
Cycle	WiSe
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC
Literature	Pfeifer, T.: Qualitätsmanagement: Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität: Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008

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.	

Course L0176: Reliability in I	Engineering Dynamics	
	Lecture	
Hrs/wk		
СР		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 min.	
scale		
Lecturer	Prof. Uwe Weltin	
Language	EN	
Cycle	SoSe	
	Method for calculation and testing of reliability of dynamic machine systems Modeling System identification Simulation Processing of measurement data Damage accumulation Test planning and execution	
Literature	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4 Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737 Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936. VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412	

Course L1303: Reliability in Engineering Dynamics	
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Courses			
Title	Тур	Hrs/wk	СР
Applied Humanoid Robotics (L1794		6	6
Module Responsible	Patrick Göttsch		
Admission Requirements	None		
Recommended Previous	Object oriented programming; algorithms and data structures		
Knowledge	Introduction to control systems		
	Control systems theory and design		
	Mechanics		
Educational Objections	After the literature of the second section of the secti		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence Knowledge			
Knowledge	Students can explain humanoid robots.		
	Students can explain the basic concepts, relationships and methods of forward- and investigations.	erse kinematics	5
	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 mod	els for robot motion o
	other tasks.	***	
	They are capable of using models in Matlab for simulation and testing these models if report such as a second control of the such as a second control of the such as a second control of the seco	ecessary with	C++ code on the rea
	robot system. • They are capable of selecting methods for solving abstract problems, for which no s	andard motho	de aro availablo, and
	apply it successfully.	andara metrio	as are available, and
Personal Competence			
Social Competence	Students can develop joint solutions in mixed teams and present these.		
	They can provide appropriate feedback to others, and constructively handle feedback to	n their own res	sults
Autonomy	Students are able to obtain required information from provided literature sources, as	d to put in in	to the context of the
	lecture.		
	They can independently define tasks and apply the appropriate means to solve them.		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Credit points			
Course achievement	None		
Examination	Written elaboration		
Examination duration and			
scale			
Assignment for the	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Com	ulsory	
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Co	mpulsory	

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

Courses	
Title	Typ Hrs/wk CP
Lab Cyber-Physical Systems (L1740	D) Project-/problem-based Learning 4 6
Module Responsible	Prof. Heiko Falk
Admission Requirements	None
Recommended Previous	Module "Embedded Systems"
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Cyber-Physical Systems (CPS) are tightly integrated with their surrounding environment, via sensors, A/D and D/A converters, are
	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. The
	lab introduces into the area (basic notions, characteristical properties) and their specification techniques (models of computatio
	hierarchical automata, data flow models, petri nets, imperative approaches). Since CPS frequently perform control tasks, the lab
	experiments will base on simple control applications. The experiments will use state-of-the-art industrial specification too
	(MATLAB/Simulink, LabVIEW, NXC) in order to model cyber-physical models that interact with the environment via sensors ar
	actors.
Skills	After successful attendance of the lab, students are able to develop simple CPS. They understand the interdependencies between
	CPS and its surrounding processes which stem from the fact that a CPS interacts with the environment via sensors, A/D converter
	digital processors, D/A converters and actors. The lab enables students to compare modelling approaches, to evaluate the
	advantages and limitations, and to decide which technique to use for a concrete task. They will be able to apply these technique
	to practical problems. They obtain first experiences in hardware-related software development, in industry-relevant specification
	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.
riacoriomy	between a die unie to dequite her intornedge non specime neducial e dia to desociate and intornedge man other education
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and	Execution and documentation of all lab experiments
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory
Following Curricula	Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory
	Computer Science: Specialisation II. Mathematics and Engineering Science: 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
	Computational Science and Engineering: Specialisation Computer Science: Elective Compulsory
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
	Mechatronics: Specialisation System Design: Elective Compulsory
	Mechatronics: Technical Complementary Course: Elective Compulsory

Course L1740: Lab Cyber-Physical 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 	

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

Course L1834: Control Lab VII	
Тур	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, Adwait Datar, Patrick Göttsch
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	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 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 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	CP
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 theory and design			
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
Knowledge	 Students can explain humanoid robots. 			
	Students learn to apply basic control concept:	s for different tasks in humanoid ro	obotics.	
Ckilla				
Skills	Students acquire knowledge about selected a	spects of humanoid robotics, base	d on specified literature	
	 Students generalize developed results and pr 	esent them to the participants		
	 Students practice to prepare and give a present 	entation		
Personal Competence				
Social Competence				
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Students are capable of developing solutions			
	 They are able to provide appropriate feedbac 	k and handle constructive criticism	n of their own results	
Autonomy	Charles to a support a share to a second describe		-ti fifi- tl	
	 Students evaluate advantages and drawbac solution 	iks of different forms of presenta	ation for specific tasks a	and select the best
	Students familiarize themselves with a scien	tific field, are able of introduce it	and follow presentation	s of other students
	such that a scientific discussion develops	and notal are able of maradace to	and ronon presentation	o or orner stadents,
	Independent Study Time 32, Study Time in Lecture 2	28		
•	2			
Course achievement	None			
Examination Examination duration and	Presentation			
examination duration and scale	30 min			
Assignment for the	Mechatronics: Specialisation Intelligent Systems and	Robotics: Flective Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Mechatronics: Specialisation System Design: Elective			
	Biomedical Engineering: Specialisation Artificial Orga	, -	ective Compulsory	
	Biomedical Engineering: Specialisation Implants and	-		
	Biomedical Engineering: Specialisation Medical Tech	nology and Control Theory: Electiv	ve Compulsory	
	Biomedical Engineering: Specialisation Management	and Business Administration: Elec	ctive Compulsory	
	Theoretical Mechanical Engineering: Technical Comp		-	
	Theoretical Mechanical Engineering: Specialisation F	Robotics and Computer Science: El	ective 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 Ident	ifikation		
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 respons State space methods Discrete-time systems Linear algebra, singular value decon Basic knowledge about stochastic processors.	nposition		
Educational Objectives	After taking part successfully, students have	ve reached the following learning results		
•	nonlinear model structures They can explain how multilayer per They can explain how an approxima They can explain the idea of subspa Students are capable of applying t models for dynamic systems They are capable of implementing a They are capable of applying subspa They can do the above using standa Students can work in mixed groups on spec	ramework of the prediction error method and receptron networks are used to model nonlinear te predictive control scheme can be based on ce identification and its relation to Kalman reache prediction error method to the experimental nonlinear predictive control scheme based or acce algorithms to the experimental identification of software tools (including the Matlab System cific problems to arrive at joint solutions.	r dynamics neural network models elisation theory ental identification of I n a neural network model on of linear models for n Identification Toolbox	inear and nonlinear lel dynamic systems
	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		rol and Power Systems Engineering: Elective C	ompulsory	
Following Curricula	Biomedical Engineering: Specialisation Imp Biomedical Engineering: Specialisation Med Biomedical Engineering: Specialisation Mar Theoretical Mechanical Engineering: Techn	n: Elective Compulsory ficial Organs and Regenerative Medicine: Elec plants and Endoprostheses: Elective Compulso dical Technology and Control Theory: Compuls nagement and Business Administration: Electiv ical Complementary Course: Elective Compuls	ry sory ve Compulsory	
	Theoretical Mechanical Engineering: Core (Qualification: Elective Compulsory		

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

Module M0939: Contr	ol Lab A			
Courses				
Title		Тур	Hrs/wk	CP
Control Lab I (L1093)		Practical Course	1	1
Control Lab II (L1291)		Practical Course	1	1
Control Lab III (L1665)		Practical Course	1	1
Control Lab IV (L1666)	T	Practical Course	1	1
Module Responsible				
Admission Requirements	None			
Recommended Previous	State space methods			
Knowledge	LQG control			
	H2 and H-infinity optimal control			
	uncertain plant models and robust con	hua!		
	· ·	troi		
	LPV control			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge				
	Students can explain the difference be	tween validation of a control lop in simulation	and experimental v	/alidation
Skills				
SKIIIS		sic system identification tools (Matlab Syste	em Identification To	olbox) to identify a
	dynamic model that can be used for co	ontroller synthesis		
		software tools (Matlab Control Toolbox) for t	he design and imp	lementation of LOG
	controllers	, , , , , , , , , , , , , , , , , , , ,		•
		ftware tools (Matlab Robust Control Toolbox)	for the mived-cencil	tivity design and the
	implementation of H-infinity optimal co		ioi tile illixed-selisii	avity design and the
				allan
		el uncertainty, and of designing and implement		
		tware tools (Matlab Robust Control Toolbox) fo	or the design and tr	ie implementation of
	LPV gain-scheduled controllers			
Personal Competence				
Social Competence				
Social competence	 Students can work in teams to conduct 	experiments and document the results		
Autonomy	Students can independently carry out s	simulation studies to design and validate cont	rol loops	
			·	
Workload in Hours	Independent Study Time 64, Study Time in Le	ecture 56		
Credit points				
Course achievement				
Examination				
Examination duration and	1			
scale				
Assignment for the			npulsory	
Following Curricula	Mechatronics: Specialisation System Design:	Elective Compulsory		
	Mechatronics: Specialisation Intelligent Syste	ms and Robotics: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical	l Complementary Course: Elective Compulsor	y	
	Theoretical Mechanical Engineering: Specialis	ation Robotics and Computer Science: Elective	re 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, Adwait Datar, Patrick Göttsch
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, Adwait Datar, Patrick Göttsch
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

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

Course L1666: Control Lab IV	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, Adwait Datar, Patrick Göttsch	
Language	EN	
Cycle	WiSe/SoSe	
Content	One of the offered experiments in control theory.	
Literature	Experiment Guides	

Module M0924: Softw	are for Embedded Systems			
Courses				
Title		Тур	Hrs/wk	СР
Software for Embdedded Systems (Lecture	2	3
Software for Embdedded Systems (Recitation Section (small)	3	3
Module Responsible	Prof. Bernd-Christian Renner			
Admission Requirements	None			
Recommended Previous	Good knowledge and experience in programn	ning language C		
Knowledge	Basis knowledge in software engineering	illig language C		
	Basic understanding of assembly language			
	Subject and ender standing of dissertion, language			
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence			·	
Knowledge	Students know the basic principles and procedures	of software engineering for embedded sy	stems. They are	able to describe the
	usage and pros of event based programming u	ising interrupts. They know the compo	nents and func	tions of a concrete
	microcontroller. The participants explain requireme	ents of real time systems. They know at I	east three sched	duling algorithms for
	real time operating systems including their pros and	I cons.		
Skills	Students build interrupt-based programs for a con	crete microcontroller. They build and us	e a preemptive	scheduler. They use
	peripheral components (timer, ADC, EEPROM) to	realize complex tasks for embedded s	systems. To inte	rface with external
	components they utilize serial protocols.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 110, Study Time in Lecture	2 70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Computer Science: Specialisation I. Computer and S	oftware Engineering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Information an	d Communication Systems: Elective Comp	ulsory	
	Information and Communication Systems: Specia	alisation Secure and Dependable IT Sy	stems, Focus S	oftware and Signal
	Processing: Elective Compulsory			
	Information and Communication Systems: Specialisa	ation Communication Systems, Focus Soft	ware: Elective Co	mpulsory
	International Management and Engineering: Special	isation II. Information Technology: Elective	Compulsory	
	Mechatronics: Technical Complementary Course: Ele	ective Compulsory		
	Mechatronics: Specialisation Intelligent Systems and	Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Electiv	e Compulsory		
	Microelectronics and Microsystems: Specialisation E	mbedded Systems: Elective Compulsory		
	Microelectronics and Microsystems: Specialisation E	mbedded Systems: Elective Compulsory		

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

Course L1070: Software for 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 (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	ne following learning results			
Professional Competence					
Knowledge	The relevance of embedded systems increases from ye embedded processors grows continuously due to its lo of embedded systems, highly optimized and applica impose high demands on compilers which have to generate students are able • to illustrate the structure and organization of successors to distinguish and explain intermediate representations.	wer costs and higher flexibility. Because tion-specific processors are deployed. S erate code of highest quality. After the su ch compilers,	of the particu uch highly sp	lar application are pecialized processo	
	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 particular,				
	 which kinds of optimizations are applicable at th how the translation from source code to assemb which kinds of optimizations are applicable at th how register allocation is performed, and 	ly code is performed, e assembly code level,			
	 how memory hierarchies can be exploited effect Since compilers for embedded systems often have to denergy dissipation, code size), the students learn to even 	ptimize for multiple objectives (e.g., aver			
Skills	After successful completion of the course, students sha be enabled to assess which kind of code optimization s assembly code) within a compiler.				
	While attending the labs, the students will learn to imp	lement a fully functional compiler includin	g optimizatior	ns.	
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 spec	ific 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 Soft				
Following Curricula	Electrical Engineering: Specialisation Information and C	·	sory		
	Aircraft Systems Engineering: Specialisation Avionic Sy	' '			
	Mechatronics: Specialisation Intelligent Systems and Ro				
	Mechatronics: Specialisation System Design: Elective C				
	Mechatronics: Technical Complementary Course: Electi				
	Theoretical Mechanical Engineering: Technical Complete				
	Theoretical Mechanical Engineering: Specialisation Rob	otics and Computer Science: Elective Con	npulsory		

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 Medic	ine			
Courses						
Title				Тур	Hrs/wk	CP
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 Schlae	efer				
Admission Requirements	None					
Recommended Previous	principles of ma	ath (algebra, analys	is/calculus)			
Knowledge		ogramming, e.g., in				
	solid R or Matla		-			
Educational Objectives	After telding part avec	and the students by	ave reached the fallow	ing leavaing results		
Educational Objectives Professional Competence	After taking part succ	essiuny, students no	ave reached the follow	ing learning results		
-	The students can exi	olain kinematics an	d tracking systems in	clinical contexts and illust	rate systems and	their components in
nnemeage.				tection and safety and re		
	systems regarding de			•		,
Ckilla	The students are able	to design and sugle	into posicionation asseture	a and valuation avatoms for m	adiaal annliaationa	
SKIIIS	The students are able	to design and evalu	iate navigation system	is and robotic systems for m	edical applications	o.
Personal Competence						
•	The students discuss	the results of other	groups, provide helpfu	I feedback and can incoorpo	rate feedback into	their work.
Autonomy	manner.	ect their knowledge	and document the re	sults of their work. They ca	n present the resu	its in an appropriate
	manner.					
Workload in Hours	Independent Study Ti	me 110, Study Time	in Lecture 70			
Credit points						
Course achievement	Compulsory Bonus Yes 10 %	Form Presentation	Description			
	Yes 10 %	Written elaboratio	n			
Examination	Written exam					
Examination duration and						
scale						
Assignment for the	Computer Science: Sp	ecialisation II: Intell	igence Engineering: El	ective Compulsory		
Following Curricula	Electrical Engineering	: Specialisation Med	lical Technology: Electi	ve Compulsory		
	_	-		ectrical Engineering: Elective		
	_	-		ocess Engineering and Biote	chnology: Elective	Compulsory
	· ·		ystems and Robotics: E		Communication	
	3	J .	3	enerative Medicine: Elective neses: Elective Compulsory	: Compuisory	
	-			Control Theory: Elective Cor	mpulsorv	
	-			ss Administration: Elective (
				Product Development: Electi		
	Product Development	, Materials and Prod	luction: Specialisation I	Production: Elective Compul	sory	
	Product Development	, Materials and Prod	luction: Specialisation I	Materials: Elective Compulso	ory	
			, ,	Course: Elective Compulsory		
	Theoretical Mechanica	al Engineering: Spec	cialisation Bio- and Med	lical Technology: Elective Co	mpulsory	

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

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

Course L0336: Robotics and Navigation in Medicine		
Тур	Recitation Section (small)	
Hrs/wk	1	
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				
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 proc	essing systems embedded into enclosi	ng products. This	s course teaches the
	foundations of such systems. In particular, it deals with	an introduction into these systems (r	otions, 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 next covers the bendunar of embodded evet	and D/A converted		abla samuningiaghian
	Another part covers the hardware of embedded syste			
	hardware, embedded processors, memories, energy di			
	introduction into real-time operating systems, middle			
	systems using hardware/software co-design (hardware		iormations or sp	ecilications, energy-
	efficient realizations, compilers for embedded processo	rs) is covered.		
Skills	After having attended the course, students shall be al	ole to realize simple embedded syste	ms. The student	s shall realize which
	relevant parts of technological competences to use in (order to obtain a functional embedded	systems. In par	ticular, they shall be
		relevant parts of technological competences to use in order to obtain a functional embedded systems. In particular, they shall be able to compare different models of computations and feasible techniques for system-level design. They shall be able to judge in		
	which areas of embedded system design specific risks of	exist.		, ,
Personal Competence				
Social Competence	Students are able to solve similar problems alone or in a	a group and to present the results acco	ordingly.	
•	·		3,	
Autonomy	Students are able to acquire new knowledge from speci	fic literature and to associate this know	vledge with other	r classes.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Desc	ription		
	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	ster): Specialisation Computer Science	:: Elective Compu	ılsory
Following Curricula	General Engineering Science (German program, 7 seme	ster): Specialisation Computer Science	: Compulsory	
	Computer Science: Specialisation Computer and Softwa	re Engineering: Elective Compulsory		
	Computer Science: Specialisation I. Computer and Softv	vare Engineering: Elective Compulsory		
	Electrical Engineering: Core Qualification: Elective Com	oulsory		
	Engineering Science: Specialisation Mechatronics: Elect	ive Compulsory		
	Aircraft Systems Engineering: Specialisation Avionic Sys	tems: Elective Compulsory		
	General Engineering Science (English program, 7 semes	ster): Specialisation Computer Science:	Elective Compu	Isory
	General Engineering Science (English program, 7 semes	ster): Specialisation Mechatronics: Elec	tive Compulsory	
	Computational Science and Engineering: Core Qualificat	cion: Compulsory		
	Mechatronics: Specialisation System Design: Elective Co	ompulsory		
	Mechatronics: Specialisation Intelligent Systems and Ro	botics: Elective Compulsory		
	Microelectronics and Microsystems: Specialisation Embe	edded 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 M0551: Patte	rn Recognition and Data Con	npression		
Courses				
Title Pattern Recognition and Data Com	pression (L0128)	Typ Lecture	Hrs/wk	CP 6
Module Responsible	Prof. Rolf-Rainer Grigat			
Admission Requirements	None			
Recommended Previous	Linear algebra (including PCA, unitary tra	nsforms), stochastics and statistics, binary arit	hmetics	
Knowledge				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence Knowledge		pattern recognition and data compression.		
	Students are able to discuss logical conrexamples.	nections between the concepts covered in the	course and to explain	i them by means of
Skills	a sound theoretical and methodical basis compression and video signal coding. T	o classification problems in pattern recognition is they can analyze characteristic value assignr They are able to use highly sophisticated me nt solution approaches in multidimensional dec	nents and classification thods and processes o	s and describe data
Personal Competence				
Social Competence	k.A.			
Autonomy	Students are capable of identifying proble	ems independently and of solving them scientif	ically, using the metho	ds they have learnt.
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	60 Minutes, Content of Lecture and mater	rials in StudIP		
scale				
Assignment for the	Computer Science: Specialisation II: Intell	ligence Engineering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Info	rmation and Communication Systems: Elective	Compulsory	
	Information and Communication System	ms: Specialisation Secure and Dependable	IT Systems, Focus So	oftware and Signal
	Processing: Elective Compulsory			
		:: Specialisation Communication Systems, Focus		ctive Compulsory
		ng: Specialisation II. Information Technology: E		
		ng: Specialisation II. Electrical Engineering: Elec	ctive Compulsory	
	Mechatronics: Specialisation intelligent Sy	ystems and Robotics: Elective Compulsory		
	Mochatronics: Tochnical Complementary	Course: Flostive Compulsors		
	Mechatronics: Technical Complementary	Course: Elective Compulsory nnical Complementary Course: Elective Compul	sorv	

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

Module 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 Lear	ning 2	2
Module Responsible	Prof. Uwe Weltin			
Admission Requirements	None			
Recommended Previous	Fundamentals of mechanics, electromechanics a	nd control theory		
Knowledge				
Educational Objectives	After taking part successfully, students have read	hed the following learning results		
Professional Competence				
Knowledge	Students are able to describe methods and calc	culations to design, model, simulate and o	ptimize mechatro	nic systems and can
	repeat methods to verify and validate models.			
Skills	Students are able to plan and execute mechati	onic experiments. Students are able to n	nodel mechatronic	systems and derive
	simulations and optimizations.			
Personal Competence				
Social Competence	Students are able to work goal-oriented in small	mixed groups, learning and broadening te	amwork abilities a	nd define task within
	the team.			
Autonomy	Students are able to solve individually exercises	related to this lecture with instructional dir	ection.	
	Students are able to plan, execute and summariz	e a mechatronic experiment.		
		70		
	Independent Study Time 110, Study Time in Lect	ure 70		
Credit points	Compulsory Bonus Form	Description		
Course achievement	Yes None Subject theoretical a	·		
	practical work			
Examination	'			
Examination duration and				
scale	30 111111			
	Electrical Engineering: Specialisation Control and	Power Systems Engineering: Elective Com	nulcony	
_	· · ·		puisoi y	
rollowing curricula	Aircraft Systems Engineering: Specialisation Avio			
	Aircraft Systems Engineering: Specialisation Aircr	, , ,		
	Mechatronics: Specialisation Intelligent Systems	·		
	Mechatronics: Specialisation System Design: Elec	tive 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	Prof. Uwe Weltin
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	Contromechanics
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Uwe Weltin
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	Prof. Uwe Weltin
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

Courses				
Title		Тур	Hrs/wk	СР
Machine Learning and Data Mining		Lecture	2	4
Machine Learning and Data Mining		Recitation Section (small)	2	2
Module Responsible				
Admission Requirements				
Recommended Previous	Calculus			
Knowledge	Stochastics			
Educational Objectives	After taking part successfully, students have read	thed the following learning results		
Professional Competence				
Knowledge	Students can explain the difference between inst	ance-based and model-based learning appr	oaches, and they	can enumerate bas
	machine learning technique for each of the t			
	incrementally incoming data . For dealing with	•	•	
	explain how axioms, features, parameters, or s			,
	algorithms. Students are also able to sketch diffe		•	
	can be improved by ensemble learning, and they	·	ational learning t	heory. Algorithms f
	reinforcement learning can also be explained by	students.		
Skills	Student derive decision trees and, in turn, prop	ositional rule sets from simple and static o	lata tables and a	re able to name a
	explain basic optimization techniques. They pres	sent and apply the basic idea of first-order	inductive leaning	g. Students apply t
	BME, MAP, ML, and EM algorithms for learning pa	arameters of Bayesian networks and compa	are the different a	algorithms. They al
	know how to carry out Gaussian mixture lear	ning. They can contrast kNN classifiers,	neural networks,	and support vect
	machines, and name their basic application area	as and algorithmic properties. Students car	describe basic	clustering technique
	and explain the basic components of those tec	hniques. Students compare related machin	ne learning techr	niques, e.g., k-mea
	clustering and nearest neighbor classification.	They can distinguish various ensemble le	earning techniqu	es and compare tl
	different goals of those techniques.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours		ure 56		
Credit points				
Course achievement				
Examination				
Examination duration and	90 minutes			
scale	Community Colonia Constitution in the Colonia Constitution	Tuning salam Election C		
Assignment for the				
Following Curricula		**	re compulsory	
	Mechatronics: Technical Complementary Course:	• •		
	Mechatronics: Specialisation Intelligent Systems			
	Mechatronics: Specialisation System Design: Elec			
	Theoretical Mechanical Engineering: Technical Co		C	
	Theoretical Mechanical Engineering: Specialisation	n Robotics and Computer Science: Elective	Compulsory	

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

Course L0510: Machine Lear	ning 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 M0623: Intell	igent Systems i	n Medicine			
Courses					
Title			Тур	Hrs/wk	СР
Intelligent Systems in Medicine (L0331)			Lecture	2	3
Intelligent Systems in Medicine (L0334)		Project Seminar	2	2	
Intelligent Systems in Medicine (L0	333)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlae	efer			
Admission Requirements	None				
Recommended Previous	a main similar of ma	oth (alaahaa analysis/salaylys)			
Knowledge		ath (algebra, analysis/calculus)			
	p		atlah		
	advanced prog	ogramming, Java/C++ and R/Ma	aciab		
	• advanced prog	ranning skiiis			
Educational Objectives	After taking part succ	essfully, students have reached	the following learning results		
Professional Competence					
Knowledge	The students are able	e to analyze and solve clinical t	reatment planning and decision suppo	ort problems using	methods for search
	optimization, and plan	nning. They are able to explain	methods for classification and their res	pective advantage	es and disadvantages
	in clinical contexts. Th	ne students can compare differ	ent methods for representing medical	knowledge. They c	an evaluate method
	in the context of clini-	cal data and explain challenge	s due to the clinical nature of the data	a and its acquisition	n and due to privacy
	and safety requirement	nts.			
Skills	The students can give	reasons for selecting and ada	pting methods for classification, regre	ession and predict	ion They can assess
Skins	_	n actual patient data and evalua		.551011, una preuiet	ion. They can assess
	ane meanous suseu of	r decadi patient data and evalue	nee and implemented methods.		
Personal Competence					
Social Competence	The students discuss	the results of other groups, pro	vide helpful feedback and can incoorpo	rate feedback into	their work.
Autonomy	The students can refl	ect their knowledge and docum	nent the results of their work. They ca	n nresent the resi	ılts in an annronriate
Autonomy	manner.	eet their knowledge and docum	ient the results of their work. They ca	ii present the rest	ares in an appropriate
	manner.				
Workload in Hours	Independent Study Ti	me 110, Study Time in Lecture	70		
Credit points	6				
Course achievement			escription		
	Yes 10 %	Written elaboration			
	Yes 10 %	Presentation			
Examination	Written exam				
Examination duration and					
scale					
Assignment for the		ecialisation II: Intelligence Engi			
Following Curricula		: Specialisation Medical Techno			
		·	ational Methods in Biomedical Imaging	: Compulsory	
	· ·	isation Intelligent Systems and			
	_		ns and Regenerative Medicine: Elective	Compulsory	
	_	- '	Endoprostheses: Elective Compulsory		
	_	- '	iology and Control Theory: Elective Con		
	_		and Business Administration: Elective (
	Theoretical Mechanica	al Engineering: Specialisation Bi	o- and Medical Technology: Elective Co	mpulsory	

Course L0221, Intelligent Cou	stone in Medicine
Course L0331: Intelligent Sys	
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 Sys	stems in Medicine
Тур	Project Seminar
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0333: Intelligent Sy	stems 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		Tun	Hrs/w	ık CP	
Industrial Process Automation (L03	344)	Typ Lecture	2	3	
Industrial Process Automation (L03		Recitation Section (sr		3	
Module Responsible	Prof. Alexander Schlaefer				
Admission Requirements	None				
Recommended Previous	mathematics and optimization methods				
Knowledge					
	principles of algorithms and data structure:	S			
	programming skills				
Educational Objectives	After taking part successfully, students have	yo reached the following learning results			
Professional Competence		re reactied the following learning results			
•	The students can evaluate and assess disc	rete event systems. They can evaluate pri	onerties of processe	es and explain m	nethods f
Mowicage	process analysis. The students can compar				
	They can discuss scheduling methods in				
	disadvantages of different programming				
	sensor systems as well as to recent topics	like 'cyberphysical systems' and 'industry	4.0'.		
Skills	The students are able to develop and mod	del processes and evaluate them accordin	gly. This involves ta	aking into accou	nt optim
	scheduling, understanding algorithmic com	plexity, and implementation using PLCs.			
Personal Competence					
•	The students work in teams to solve proble	ems.			
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,					
Autonomy	The students can reflect their knowledge a	nd document the results of their work.			
·					
Workload in Hours	Independent Study Time 124, Study Time i	n Lecture 56			
Workload in Hours Credit points		n Lecture 56			
	6	n Lecture 56 Description			
Credit points	6				
Credit points Course achievement Examination	6 Compulsory Bonus Form No 10 % Excercises Written exam				
Credit points Course achievement Examination Examination duration and	6 Compulsory Bonus Form No 10 % Excercises Written exam				
Credit points Course achievement Examination Examination duration and scale	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes	Description			
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - 6	Description General Bioprocess Engineering: Elective C			
Credit points Course achievement Examination Examination duration and scale	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - Chemical and Bioprocess Engineering: Specialisation Speciali	Description General Bioprocess Engineering: Elective Cialisation Chemical Process Engineering:	Elective Compulsory	,	
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - Chemical and Bioprocess Engineering: Specialisation Chemical and Bioprocess Engineering: Specialisation S	Description General Bioprocess Engineering: Elective C cialisation Chemical Process Engineering: Elective C cialisation General Process Engineering: Elective C	Elective Compulsory	,	
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - C Chemical and Bioprocess Engineering: Spe Chemical and Bioprocess Engineering: Spe Computer Science: Specialisation II: Intellig	Description General Bioprocess Engineering: Elective Concilisation Chemical Process Engineering: Elective Concilisation General Process Engineering: Elective Compulsory	Elective Compulsory lective Compulsory	/	
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - Chemical and Bioprocess Engineering: Specialisation Chemical and Bioprocess Engineering: Specialisation S	Description General Bioprocess Engineering: Elective Concilisation Chemical Process Engineering: Elective Congulation General Process Engineering: Elence Engineering: Elective Compulsory of and Power Systems Engineering: Elective	Elective Compulsory lective Compulsory	/	
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - Chemical and Bioprocess Engineering: Specialisation Chemical and Bioprocess Engineering: Specialisation II: Intelligent Electrical Engineering: Specialisation Control of the Computer Science: Specialisation	Description General Bioprocess Engineering: Elective Concilisation Chemical Process Engineering: Elective Congulation General Process Engineering: Elence Engineering: Elective Compulsory of and Power Systems Engineering: Elective ation: Elective Compulsory	Elective Compulsory lective Compulsory	/	
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - Chemical and Bioprocess Engineering: Spechemical and Bioprocess Engineering: Spechemical and Bioprocess Engineering: Spechemical Engineering: Specialisation II: Intelliging Electrical Engineering: Specialisation Contradircraft Systems Engineering: Core Qualific	Description General Bioprocess Engineering: Elective Compulsory cialisation Chemical Process Engineering: Elective Compulsory of and Power Systems Engineering: Elective Compulsory of Cabin Systems: Elective Compulsory	Elective Compulsory lective Compulsory ve Compulsory	/	
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - Chemical and Bioprocess Engineering: Specialisation and Bioprocess Engineering: Specomputer Science: Specialisation II: Intelligent Electrical Engineering: Specialisation Contraction Aircraft Systems Engineering: Core Qualification Aircraft Systems Engineering: Specialisation	Description General Bioprocess Engineering: Elective Concideration Chemical Process Engineering: Elective Congulation General Process Engineering: Elective Compulsory of and Power Systems Engineering: Electivation: Elective Compulsory In Cabin Systems: Elective Compulsory In Specialisation II. Mechatronics: Elective General Process Engineering: Elective General Pr	Elective Compulsory lective Compulsory ve Compulsory Compulsory		
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - Chemical and Bioprocess Engineering: Specialisation and Bioprocess Engineering: Specialisation and Bioprocess Engineering: Specialisation II: Intellige Electrical Engineering: Specialisation Contraircraft Systems Engineering: Core Qualific Aircraft Systems Engineering: Specialisatio International Management and Engineering	Description General Bioprocess Engineering: Elective Concideration Chemical Process Engineering: Elective Congulation General Process Engineering: Elective Compulsory of and Power Systems Engineering: Elective Compulsory in Cabin Systems: Elective Compulsory graphs: Specialisation II. Mechatronics: Elective Corrections of the Specialisation II. Product Development and Specialisation III. Product Development and Specialis	Elective Compulsory lective Compulsory ve Compulsory Compulsory and Production: Elective		
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - Chemical and Bioprocess Engineering: Specialisation and Engineering: Specialisation II: Intelligible Electrical Engineering: Specialisation Contraction Aircraft Systems Engineering: Core Qualific Aircraft Systems Engineering: Specialisatio International Management and Engineering International Management and Engineering	Description General Bioprocess Engineering: Elective Contains and Con	Elective Compulsory lective Compulsory ve Compulsory Compulsory and Production: Elective		
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - Chemical and Bioprocess Engineering: Specialisation and Special and Bioprocess Engineering: Specialisation II: Intelliging Electrical Engineering: Specialisation Contraction Aircraft Systems Engineering: Core Qualific Aircraft Systems Engineering: Specialisatio International Management and Engineering International Management and Engineering Mechanical Engineering and Management:	Description General Bioprocess Engineering: Elective Condition Chemical Process Engineering: Elective Condition General Process Engineering: Elective Compulsory of and Power Systems Engineering: Electivation: Elective Compulsory on Cabin Systems: Elective Compulsory on Specialisation II. Mechatronics: Elective Compulsory on Cabin Systems: Elective Cabin S	Elective Compulsory lective Compulsory ve Compulsory Compulsory and Production: Elections	tive Compulsory	
Credit points Course achievement Examination Examination duration and scale Assignment for the	6 Compulsory Bonus Form No 10 % Excercises Written exam 90 minutes Bioprocess Engineering: Specialisation A - Chemical and Bioprocess Engineering: Specialisation II: Intelligent Electrical Engineering: Specialisation II: Intelligent Electrical Engineering: Specialisation Contradircraft Systems Engineering: Core Qualific Aircraft Systems Engineering: Specialisation International Management and Engineering International Management and Engineering Mechanical Engineering and Management: Mechatronics: Specialisation Intelligent Systems	Description General Bioprocess Engineering: Elective Condition Chemical Process Engineering: Elective Condition General Process Engineering: Elective Compulsory of and Power Systems Engineering: Elective Elective Compulsory on Cabin Systems: Elective Elective Compulsory on Cabin Systems: Elective Cabin Sys	Elective Compulsory lective Compulsory ve Compulsory Compulsory and Production: Elective Elective Compulsory	tive Compulsory	

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	

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

Courses	
Title	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 Describe the abusing of concerns
	 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 of the su
	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.
	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 Studie
Assignment for the	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory
Following Curricula	
. Shoming curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory
	Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Software and 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	4	
СР	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Rolf-Rainer Grigat	
Language	EN	
Cycle	WiSe	
Content	 Image representation, definition of images and volume data sets, illumination, radiometry, multispectral imaging, reflectivities, shape from shading Perception of luminance and color, color spaces and transforms, color matching functions, human visual system, color appearance models imaging sensors (CMOS, CCD, HDR, X-ray, IR), sensor characterization(EMVA1288), lenses and optics spatio-temporal sampling (interpolation, decimation, aliasing, leakage, moiré, flicker, apertures) features (filters, edge detection, morphology, invariance, statistical features, texture) optical flow (variational methods, quadratic optimization, Euler-Lagrange equations) segmentation (distance, region growing, cluster analysis, active contours, level sets, energy minimization and graph cuts) registration (distance and similarity, variational calculus, iterative closest points) 	
Literature	Bredies/Lorenz, Mathematische Bildverarbeitung, Vieweg, 2011 Wedel/Cremers, Stereo Scene Flow for 3D Motion Analysis, Springer 2011 Handels, Medizinische Bildverarbeitung, Vieweg, 2000 Pratt, Digital Image Processing, Wiley, 2001 Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1989	

Module 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		matrix inequalities		
Knowledge		mann mequanics		
	After taking part successfully, students have reached the	following learning results		
Professional Competence	The calling part succession, stadenes have rederied the	Tonorming rearrang results		
Knowledge				
Knowledge	 Students can explain the advantages and shortcon 	nings of the classical gain scheduling	approach	
	They can explain the representation of nonlinear syllands.	ystems in the form of quasi-LPV syst	ems	
	They can explain how stability and performance co	nditions for LPV systems can be form	nulated as LMI co	nditions
	They can explain how gridding techniques can be u	used to solve analysis and synthesis	problems for LPV	systems
	 They are familiar with polytopic and LFT repres 	entations of LPV systems and som	e of the basic s	ynthesis techniques
	associated with each of these model structures			
	Students can explain how graph theoretic conce	epts are used to represent the co	mmunication top	ology of multiagent
	systems			
	They can explain the convergence properties of fine			
	 They can explain analysis and synthesis conditions 	for formation control loops involving	g either LTI or LP	/ agent models
	Students can explain the state space representation	on of spatially invariant distributed s	ystems that are o	discretized according
	to an actuator/sensor array	a become dead on all leaves to be excellent to	hallo a karal ara a karara	
	They can explain (in outline) the extension of the synthesis conditions for distributed controllers.	e bounded real lemma to such dis	tributed systems	and the associated
	synthesis conditions for distributed controllers			
Skills	Students are capable of constructing LPV model	s of nonlinear plants and carry out	a mixed-sensit	vity design of gain-
	scheduled controllers; they can do this using polyti		a mixeu-sensic	vity design or gam-
	They are able to use standard software tools (Matla		asks	
	They are usic to use standard sorthare tools (Hath		asks	
	 Students are able to design distributed formation 	controllers for groups of agents wi	th either LTI or I	.PV dynamics, using
	Matlab tools provided			,
	·			
	Students are able to design distributed controllers	for spatially interconnected systems	, using the Matla	b MD-toolbox
Personal Competence				
·	Students can work in small groups and arrive at joint resu		- 6	
Autonomy	'	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 56			
Credit points	, ,			
Course achievement	None			
Examination	Oral exam			
Examination duration and				
scale				
Assignment for the	Electrical Engineering: Specialisation Control and Power S	ystems Engineering: Elective Compu	ılsory	
Following Curricula	Aircraft Systems Engineering: Specialisation Avionic Syste		-	
_	Aircraft Systems Engineering: Specialisation Aircraft Systems	• •		
	Aircraft Systems Engineering: Core Qualification: Elective			
	International Management and Engineering: Specialisatio		ory	
	Mechatronics: Specialisation System Design: Elective Con	npulsory		
	Mechatronics: Specialisation Intelligent Systems and Rob	otics: Elective Compulsory		
	Biomedical Engineering: Specialisation Implants and Endo	pprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technolog	y and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management and	Business Administration: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation Artificial Organs a	-		
	Theoretical Mechanical Engineering: Specialisation Robot	ics and Computer Science: Elective C	Compulsory	

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

Course L0662: Advanced Top	ourse 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 M0677: Digita	al Signal Processing and Digital Filte	ers		
Courses				
Title Digital Signal Processing and Digital Filters (L0446) Digital Signal Processing and Digital Filters (L0447)		Typ Lecture Recitation Section (large)	Hrs/wk 3 2	CP 4 2
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge	Mathematics 1-3 Signals and Systems Fundamentals of signal and system theory as Fundamentals of spectral transforms (Fourier)	•	sform)	
Educational Objectives	After taking part successfully, students have reached	d the following learning results		
Professional Competence				
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 tutorial problems, software tools, clicker system.			
Wanted and In Harris	Indiana dest Study Time 110 Study Time in Last une	70		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 6	/0		
Credit points Course achievement				
Examination				
Examination duration and				
scale				
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Por Computational Science and Engineering: Specialisati Information and Communication Systems: Specialisa Mechanical Engineering and Management: Specialisa Mechatronics: Specialisation Intelligent Systems and Microelectronics and Microsystems: Specialisation Co Theoretical Mechanical Engineering: Specialisation R	on II. Engineering Science: Elective Co tion Communication Systems, Focus S ation Mechatronics: Elective Compulson Robotics: Elective Compulsory ommunication and Signal Processing: E	mpulsory gnal Processing: El y clective 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 flter theory.	
	L. B. Jackson: Digital filters and signal processing. Kluwer.	
	T.W. Parks, C.S. Burrus: Digital filter design. Wiley.	

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

Module M1173: Appli	d Statistics				
Courses					
Title		Тур		Hrs/wk	СР
Applied Statistics (L1584)		Lectur	e	2	3
Applied Statistics (L1586)		Project	t-/problem-based Learning	2	2
Applied Statistics (L1585)		Recita	tion 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, studer	its have reached the following lear	ning results		
Professional Competence					
Knowledge	Students can explain the statistical r	nethods and the conditions of their	use.		
-	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results				
Personal Competence			•	·	
•	Feam Work, joined presentation of re	esults			
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	,,,,				
Autonomy	Γο understand and interpret the que	stion and solve			
Workload in Hours	ndependent Study Time 110, Study	Time in Lecture 70			
Credit points					
Course achievement	Compulsory Bonus Form	Description			
course acmevement	Yes None Written elabo	·			
Examination	Written exam				
Examination duration and	90 minutes, 28 questions				
scale	· · · · · · · · · · · · · · · · · ·				
	Mechanical Engineering and Manage	ment: Specialisation Management:	Flective Compulsory		
•	Mechatronics: Specialisation System	,			
g carricula	Mechatronics: Specialisation Intellige		Compulsory		
	Biomedical Engineering: Core Qualifi	•			
	Product Development, Materials and	' '	ctive Compulsory		
	Theoretical Mechanical Engineering:	· ·	, ,	lsory	

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

Course L1586: Applied Statis	stics
Тур	Project-/problem-based Learning
Hrs/wk	2
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

elling and Optimization in Dynamics			
c) s (1.1633)	Typ Lecture Lecture	Hrs/wk 2 2	CP 3
Mathematics I, II, III Mechanics I, II, III, IV Simulation of dynamical Systems			
After taking part successfully, students have reached	I the following learning results		
			x rigid and flexible
Students are able			
+ to think holistically			
+ to independently, securly and critically analyze a systems	and optimize basic problems of	the dynamics of rigid and	d flexible multibody
+ to describe dynamics problems mathematically			
+ to optimize dynamics problems			
Students are able to + solve problems in heterogeneous groups and to do	cument the corresponding resul	ts.	
Students are able to			
+ assess their knowledge by means of exercises.			
+ acquaint themselves with the necessary knowledge	e to solve research oriented task	KS.	
Independent Study Time 124, Study Time in Lecture	56		
6			
None			
Oral exam			
30 min			
	•		
, , , , , ,			
		sorv	
,	·	- •	
	Prof. Robert Seifried None • Mathematics I, II, III • Mechanics I, II, IIII • Mechanics I, III, IIII • Mechanics I, IIII • Mechani	Typ Lecture (L1633) Lecture Prof. Robert Seifried None • Mathematics I, II, III • Mechanics I, II, IIII • Mecharics I, II, IIII • Mecharics I, III, III • Mecharics I, III, IIII • Mecharics I, III, III, III • Mecharics I, III, IIII • Mecharics I, III, IIII • Mecharics I, III, IIII • Mecharics I, III, III, III • Mecharics I, IIII, III, III • Mecharics I, III, III, III • Mecharics I, III, III, III, III • Mecharics I, III, III, IIII • Mecharics I, III, III, III • Mecharics I, III, III, III, IIII • Mecharics I, III, III, III, III • Mecharics I, IIII, III, III • Mecharics I, IIII, III, III, IIII • Mecharics I, III, III, III, IIII • Mecharics I, IIII, IIII, IIII • Mecharics I, III, IIII, III, IIII • Mecharics I, IIII, III, IIII • Mecharics I, IIIIII, IIII • Mecharics I, IIII, IIII • Mecharics I, IIII, IIII • Mecharics I, IIII, IIII • Mecharics I, IIIII • Mecharics I, IIIIII • Mecharics I, IIII • Mecharics I, IIII • Mecharics I, IIII • Mecharics I, IIII • Mecharics I, IIII • Mecharics I, IIII • Mecharics I, IIII • Mecharics I, IIII • Mecharics I, IIII • Mecharics I, IIII • Mecharics I, IIII • Mecharics III • Mecharics I	Typ Hrs/wk Lecture 2 Lecture 2 Prof. Robert Selfried None • Mathematics I, II, III • Mechanics I, III, IIII • Mechanics I, III, IIII • Mechanics I, III, IIII • Michanics III, IIII, IIII • Michanics III, IIIII • Michanics III, IIII • Michanics III, IIIII • Michanics IIII, IIIII • Michanics IIII, IIIII • Michanics IIIIIIII • Michanics IIIIIIIIII • Michanics IIIIIIIIIII • Michanics IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII

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	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, Dr. Alexander Held
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 M1229: Contr	ol Lab B			
Courses				
Title		Тур	Hrs/wk	СР
Control Lab V (L1667)		Practical Course	1	1
Control Lab VI (L1668)		Practical Course	1	1
Module Responsible	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 conti	rol		
	LPV control			
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence				
Knowledge	Students can explain the difference bet	ween validation of a control lop in simulatio	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 			
	controllers	oftware tools (Matlab Control Toolbox) for tware tools (Matlab Robust Control Toolbox)		
	implementation of H-infinity optimal cor			
	They are capable of representing model	uncertainty, and of designing and impleme	enting a robust contro	oller
	 They are capable of using standard soft LPV gain-scheduled controllers 	ware tools (Matlab Robust Control Toolbox)	for the design and th	e implementation of
Personal Competence				
Social Competence	Students can work in teams to conduct	experiments and document the results		
Autonomy	Students can independently carry out si	mulation studies to design and validate cor	ntrol loops	
Workload in Hours	Independent Study Time 32, Study Time in Led	ture 28		
Credit points	2			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	1			
scale	Flootrical Engineerings Consistentian Control	and Downer Cymbons English and The Co	manula an i	
Assignment for the	- · ·		mpuisory	
Following Curricula	, , , , , , , , , , , , , , , , , , , ,			
	Mechatronics: Specialisation System Design: E	iective Compulsory		

Course L1667: Control Lab V	urse 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, Adwait Datar, Patrick Göttsch		
Language	EN		
Cycle	WiSe/SoSe		
Content	One of the offered experiments in control theory.		
Literature	Experiment Guides		

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

Module M1305: 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 reac	hed the following learning results		
Professional Competence				
Knowledge	Students can explain modern control. Students learn to apply basic control conce	epts 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 solutio They are able to provide appropriate feedby	•	f their own results	
Autonomy	Students evaluate advantages and drawl solution Students familiarize themselves with a sc such that a scientific discussion develops	·		
Workload in Hours	Independent Study Time 32, Study Time in Lectur	re 28		
Credit points	2			
Course achievement	None			
Examination	Presentation		·	
Examination duration and scale	90 min			
Assignment for the	Mechatronics: Specialisation System Design: Elec	tive Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems a	and Robotics: Elective Compulsory		

Course 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 an	d Robotics				
Courses						
Title		Тур	Hrs/wk	СР		
Formulas and Vehicles - Mathemat	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 Equation	s				
	Control Systems Theory and Design					
Educational Objectives	After taking part successfully, students have reached	the following learning results				
Professional Competence						
Knowledge	After successful completion of the module students demonstrate deeper knowledge and understanding in selected application areas of multibody dynamics and robotics			selected application		
Skills	Students are able					
	+ to think holistically	+ to think holistically				
	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody systems					
	+ to describe dynamics problems mathematically					
	+ to implement dynamical problems on hardware					
Personal Competence						
Social Competence	Students are able to					
	+ solve problems in heterogeneous groups and to doc	rument the corresponding results and prese	ent them			
Autonomy	Students are able to					
	+ assess their knowledge by means of exercises and	projects.				
	+ acquaint themselves with the necessary knowledge	to solve research oriented tasks.				
Workload in Hours	Independent Study Time 152, Study Time in Lecture 2	8				
Credit points	6					
Course achievement	None					
Examination	Presentation					
Examination duration and scale						
Assignment for the		Robotics: Elective Compulsory				
Following Curricula						
	Theoretical Mechanical Engineering: Core Qualification	n: 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 M1552: Mathe	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			
,	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	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 n	eural networks.	
Personal Competence	Charlestone			
Social Competence	Students can			
	 develop and document joint solutions in small tea 	ams;		
	 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	actical excercises are better solved in	ndividually or in a	team;
	 define test problems for testing and expanding the 	ne methods;		
	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	ive Compulsory		
Following Curricula	1 .		,	
	Mechatronics: Specialisation Intelligent Systems and Ro			
	Mechatronics: Technical Complementary Course: Electiv			
	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	1. Skript 2. 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		

Module M0629: Intelli	igent Autonomous Agents and Co	gnitive 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 reac	hed the following learning results		
Professional Competence				
	Students can explain the agent abstraction, defir (goals, utilities, environments). They can describe can be discussed in terms of decision problems world scenarios, students can summarize how Be 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 protocome students can derive decision trees and apply bas networks/dynamic Bayesian networks and appl 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.	e the main features of environments. The and algorithms for solving these problem ayesian networks can be employed as a k lition, students can define decision making state of the environment. In this context roblems, and they can recall techniques to us localization and mapping, and can exployed problems and decision making in a multicular, and mechanism design techniques. Secture for concrete agent application scensic optimization techniques. For those apply bayesian reasoning for simple queries at scenarios. For simple and complex deciviting apply to the same and apply to the same applications students will apply to the same application scenarios. For simple and complex deciviting apply to the same application students will apply to the same applications students will apply to the same applications are same applications and complex deciviting applications students will apply to the same applications are same applications and same applications are same applications are same applications are same applications and same applications are same	notion of adversarins. For dealing with nowledge represent grocedures in sit, students can desfor measuring the polain planning technagent setting in technagent setting in technagent setting students. Students can alision making stude echniques for findings.	ial agent cooperation in uncertainty in real- station and reasoning imple and sequential scribe techniques for value of information. Iniques for achieving erm of different types ed agent application also create Bayesian Iso name and apply ints can compute the ng different equilibria
Personal Competence	Chudonka ava abla ta diagram their selection	blone with athers There are a second		
Social Competence	Students are able to discuss their solutions to pro	blems with others. They communicate in i	English	
Autonomy	Students are able of checking their understanding	g of complex concepts by solving varaints	of concrete probler	ms
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ure 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
	Computer Science: Specialisation II: Intelligence E		ivo Compulsori	
Following Curricula	International Management and Engineering: Spec Mechatronics: Technical Complementary Course:	**	ive compulsory	
	Mechatronics: Specialisation Intelligent Systems a	• •		
	Biomedical Engineering: Specialisation Artificial O		e Compulsory	
	Biomedical Engineering: Specialisation Implants a			
	Biomedical Engineering: Specialisation Medical Te		mpulsory	
	Biomedical Engineering: Specialisation Manageme			
	Theoretical Mechanical Engineering: Specialisatio	n Robotics and Computer Science: Elective	e 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
Language	EN
Cycle	
Content	
30	 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	
Littidule	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
	Onversity 11633, 2003

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 M0881: Matho	ematical Image Processing			
Courses				
Title		Тур	Hrs/wk	СР
Mathematical Image Processing (LC	9991)	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, gradient, direction			
	Linear Algebra: eigenvalues, least squares soli	ution of a linear system		
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	Students are able to			
	a have sharing and someone differsion occuptions			
	 characterize and compare diffusion equations explain elementary methods of image process 	ina		
	explain elementary methods of image process explain methods of image segmentation and r	-		
	sketch and interrelate basic concepts of functions			
		onar anarysis		
Skills	Students are able to			
	 implement and apply elementary methods of i 	mage processing		
	explain and apply modern methods of image p	processing		
Personal Competence				
Social Competence	Students are able to work together in heteroge background knowledge) and to explain theoretical fo		from different St	udy programs and
Autonomy				
	 Students are capable of checking their under 	standing of complex concepts on their	own. They can spe	cify open questions
	precisely and know where to get help in solvin			
	Students have developed sufficient persisten	ce to be able to work for longer period	ds in a goal-orient	ed 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 - General Bi	oprocess Engineering: Elective Compuls	ory	
Following Curricula	Computer Science: Specialisation III. Mathematics: El	ective Compulsory		
	Computational Science and Engineering: Specialisation			
	Interdisciplinary Mathematics: Specialisation Comput		Compulsory	
	Mechatronics: Technical Complementary Course: Ele	• •		
	Mechatronics: Specialisation System Design: Elective			
	Mechatronics: Specialisation Intelligent Systems and			
	Technomathematics: Specialisation I. Mathematics: E Theoretical Mechanical Engineering: Specialisation R	• •	Compulsory	
	Process Engineering: Specialisation Process Engineer	·	Compuisory	
	r rocess Engineering. Specialisation riocess Engineer	ing. Liective 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: 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 Knowledge	Calculus Linear Algebra Engineering Mechanics			
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 in Nonlinear Dynamics and to develop and research new terms and concepts.			
Skills	Students are able to apply existing methods and proces	sures 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 ind	ividually 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: Specialisation Aircraft Sy	stems: Elective Compulsory		
Following Curricula	International Management and Engineering: Specialisat	ion II. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management: Specialisation	·	ry	
	Mechatronics: Specialisation System Design: Elective C			
	Mechatronics: Specialisation Intelligent Systems and Ro	• •		
	Biomedical Engineering: Specialisation Artificial Organs	-		
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Technol			
	Biomedical Engineering: Specialisation Management an		Compulsory	
	Product Development, Materials and Production: Core C Theoretical Mechanical Engineering: Technical Compler		n/	
	Theoretical Mechanical Engineering: Technical Completed Theoretical Mechanical Engineering: Core Qualification:		' y	
	Theoretical Mechanical Engineering, Core Qualification.	Liective Compulsory		

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

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 the	ollowing learning results		
Professional Competence				
Knowledge	Embedded systems can be defined as information process	ing systems embedded into enclos	sing products. This	s course teaches the
	foundations of such systems. In particular, it deals with a	n introduction into these systems	notions, common	characteristics) and
	their specification languages (models of computation, hi	erarchical automata, specification	of distributed sy	stems, task graphs,
	specification of real-time applications, translations betwee	n different models).		
	Another part covers the hardware of embedded system	s: Sonsors A/D and D/A converts	ers real-time can	able communication
	hardware, embedded processors, memories, energy dissi			
	introduction into real-time operating systems, middlewa			
	systems using hardware/software co-design (hardware/so			
	efficient realizations, compilers for embedded processors)			3,
	,			
Skills	After having attended the course, students shall be able			
		relevant parts of technological competences to use in order to obtain a functional embedded systems. In particular, they shall be		
	able to compare different models of computations and feasible techniques for system-level design. They shall be able to judge in			
	which areas of embedded system design specific risks exis	t.		
Personal Competence				
Social Competence	Students are able to solve similar problems alone or in a g	roup and to present the results acc	cordingly.	
Autonomy	Students are able to acquire new knowledge from specific	literature and to associate this kno	wledge with othe	r classes.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Descript	ion		
	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 semeste	er): Specialisation Computer Science	e: Elective Compu	ulsory
Following Curricula	General Engineering Science (German program, 7 semeste		e: Compulsory	
	Computer Science: Specialisation Computer and Software			
	Computer Science: Specialisation I. Computer and Softwar		<i>y</i>	
	Electrical Engineering: Core Qualification: Elective Compul	,		
	Engineering Science: Specialisation Mechatronics: Elective	' '		
	Aircraft Systems Engineering: Specialisation Avionic Syste		o. Elective Commi	lson
	General Engineering Science (English program, 7 semeste General Engineering Science (English program, 7 semeste			-
	Computational Science and Engineering: Core Qualification		cuve compuisory	
	Mechatronics: Specialisation System Design: Elective Com			
	Mechatronics: Specialisation Intelligent Systems and Robo			
	Microelectronics and Microsystems: Specialisation Embedo			
	Microelectronics and Microsystems: Specialisation Embedo	eu 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 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		Тур	Hrs/wk	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 Mechan	nics II (Hydrostatics, Kinematics, Dyna	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 acousti	cs regarding acoustic waves, noise p	protection, and p	sycho acoustics and
	are able to give an overview of the corresponding theore	tical and methodical basis.		
Skille	The students are capable to handle engineering p	robloms in acquetics by theory ba	scod application	of the demanding
Skills	methodologies and measurement procedures treated wi		ised application	or the demanding
	methodologies and medsarement procedures treated wi	ann the module.		
Personal Competence				
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.			
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible			
	conflicting issues and limitations can be identified and th	•		
	,			
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				
Following Curricula	Aircraft Systems Engineering: Specialisation Cabin Syste	• •		
	International Management and Engineering: Specialisation	·	oulsory	
	Mechatronics: Specialisation System Design: Elective Co	•		
	Product Development, Materials and Production: Core Qu	• •		
	Technomathematics: Specialisation III. Engineering Scien	• •		
	Theoretical Mechanical Engineering: Technical Complem		tivo Compulsory	
	Theoretical Mechanical Engineering: Specialisation Produ	ct Development and Production: Elec	ctive Compulsory	

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

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

Courses					
itle			Тур	Hrs/wk	СР
Boundary Element Methods (L0523)		Lecture	2	3
Boundary Element Methods (L0524)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff				
Admission Requirements	None				
Recommended Previous	Mechanics I (Statics, Mech	nanics of Materials) ar	d Mechanics II (Hydrostatics, Kinematics, D	ynamics)	
Knowledge	Mathematics I, II, III (in pa	rticular differential eq	uations)		
Educational Objectives	After taking part successf	ully, students have re	ached the following learning results		
Professional Competence	3	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			
Knowledge	The students possess an	in-depth knowledge i	regarding the derivation of the boundary e	lement method and	d are able to give
	overview of the theoretica				g
Skills	The students are capak	ole to handle engin	eering problems by formulating suitable	boundary eleme	nts. assembling t
			e resulting system of equations.	, , , , , , , , , , , , , , , , , , , ,	, y
ļ					
ļ					
ļ					
Personal Competence					
Social Competence	Students can work in small	II groups on specific p	roblems to arrive at joint solutions.		
A	The students are able to	to decrease desertive and the	shallow size a consequent in a shallow a larger		
Autonomy			challenging computational problems and d	evelop own bounda	ary element routine
ļ.	Problems can be identified	and the results are o	critically scrutinized.		
ļ.					
ļ.					
Workload in Hours	Independent Study Time 1	124. Study Time in Le	cture 56		
Credit points	6	, ,			
Course achievement	Compulsory Bonus For	m	Description		
course acmevement		dterm	·		
Examination	Written exam				
Examination duration and	90 min				
scale	30 111111				
	Civil Engineering: Speciali	cation Structural Engi	neering: Elective Compulsory		
Assignment for the		_			
Following Curricula			ngineering: Elective Compulsory		
			ering: Elective Compulsory		
	Energy Systems: Core Qua			tion, Floctive Comm	ulcon/
			cialisation Product Development and Produc	Lion: Elective Comp	ouis01 y
	Mechatronics: Specialisati				
			: Core Qualification: Elective Compulsory		
			ring Science: Elective Compulsory		
	•	_	ring Science: Elective Compulsory Complementary Course: Elective Compulsor		

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

Course L0524: Boundary Eler	ourse 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 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	nsidering 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		3 ,	
Personal Competence				
Social Competence	Students will solve and execute technical-scientific tasks fr	om 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	design
	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and	30 min Presentation for a group design-work			
scale				
Assignment for the	International Management and Engineering: Specialisation II.	Product Development and Production	on: Elective Cor	npulsory
Following Curricula	International Management and Engineering: Specialisation II.	Mechatronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation Prod	uct Development and Production: I	Elective Compu	sory
	Mechatronics: Specialisation System Design: Elective Compuls	sory		
	Biomedical Engineering: Specialisation Artificial Organs and R	egenerative Medicine: Elective Con	npulsory	
	Biomedical Engineering: Specialisation Implants and Endopros	theses: Elective Compulsory		
	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		

Course L1523: Applied Desig	n Methodology in Mechatronics
Тур	Lecture
Hrs/wk	[2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	 Systematic analysis and planning of the design process for products combining a multitude of disciplines Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation) Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics) Several design-supporting methods and tools (functional 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 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	following learning results			
Professional Competence					
Knowledge	Students are able to:				
	 understand systems engineering process models, method 	ods and tools for the development of	f complex System	ıs	
	describe innovation processes and the need for technological contents.	ogy Management			
	explain the aircraft development process and the proces	ss of type certification for aircraft			
	explain the system development process, including requ	irements for systems reliability			
	identify environmental conditions and test procedures for	or airborne Equipment			
	value the methodology of requirements-based engineeri	ng (RBE) and model-based requirer	ments engineering	(MBRE)	
Skills	Students are able to:				
	plan the process for the development of complex System	ns			
	organize the development phases and development Tasks				
	• assign required business activities and technical Tasks				
	apply systems engineering methods and tools				
Davasual Commetence					
Personal Competence	Chudanta are able to:				
Social Competence	Students are able to:	ann and interrete thereaches with	their rele in the e	verall presses	
	understand their responsibilities within a development to	earn 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	6				
Course achievement					
Examination	Written exam				
Examination duration and	120 Minutes				
scale					
Assignment for the	Aircraft Systems Engineering: Core Qualification: Compuls	ory			
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 Com				
	Mechatronics: Specialisation Intelligent Systems and Robo	tics: Elective Compulsory			
	Product Development, Materials and Production: Specialise	ation Product Development: Compu	lsory		
	Product Development, Materials and Production: Specialis	ation Production: Elective Compulso	ory		
	Product Development, Materials and Production: Specialise	ation Materials: Elective Compulsor	у		
	Theoretical Mechanical Engineering: Technical Complement				
	Theoretical Mechanical Engineering: Specialisation Aircraft	t 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	Typ Hrs/wk CP			
Module Responsible	Prof. Uwe Weltin			
Admission Requirements	None			
Recommended Previous	See selected module according to FSPO			
Knowledge				
	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	see selected module according to FSPO			
Skills	see selected module according to FSPO			
Personal Competence				
•	see selected module according to FSPO			
Social Competence	see selected module according to rspo			
Autonom	see selected module according to FSPO			
Autonomy	see selected module according to FSPO			
Workload in Hours	Depends on choice of courses			
Credit points				
	Mechatronics: Specialisation System Design: Elective Compulsory			
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory			

Module M1223: Selec	ted Topics of Mechatronics (Alternat	tive A: 12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Applied Automation (L1592)		Project-/problem-based Learning	3	3
Development Management for Med	hatronics (L1512)	Lecture	2	3
Fatigue & Damage Tolerance (L031	LO)	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
Six Sigma (L1130)		Lecture	2	3
Applied Dynamics (L1630)		Lecture	2	3
Reliability in Engineering Dynamics		Lecture	2	2
Reliability in Engineering Dynamics	s (L1303)	Recitation Section (small)	1	2
Module Responsible	Prof. Uwe Weltin			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	 Students are able to express their extended knowledge and discuss the connection of different special fields or application areas of mechatronics Students are qualified to connect different special fields with each other 			
Skills	 Students can 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 develop own solution approaches 			
Personal Competence				
Social Competence	None			
Autonomy	Students are able to develop their knowledge a	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	Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and I	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 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	Dr. Johannes Nicolas Gebhardt, Dr. Daniel Steffen
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
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, 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; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensors: galavanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors (galvanomagnetic sensors) Magnetic Sensors
Lihoundouro	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	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	- Färber: "Prozeßrechentechnik", Springer-Verlag 1994
	- Kiencke, Kronmüller: "Meßtechnik", Springer Verlag Berlin Heidelberg, 1995
	- A. Ambardar: "Analog and Digital Signal Processing" (1), PWS Publishing Company, 1995, NTC 339
	- A. Papoulis: "Signal Analysis" (1), McGraw-Hill, 1987, NTC 312 (LB)
	- M. Schwartz: "Information Transmission, Modulation and Noise" (3,4), McGraw-Hill, 1980, 2402095
	- S. Haykin: "Communication Systems" (1,3), Wiley&Sons, 1983, 2419072
	- H. Sheingold: "Analog-Digital Conversion Handbook" (5), Prentice-Hall, 1986, 2440072
	- J. Fraden: "AIP Handbook of Modern Sensors" (5,6), American Institute of Physics, 1993, MTB 346

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

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

Course L1130: Six Sigma	
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 Minuten
scale	
Lecturer	Prof. Claus Emmelmann
Language	DE
Cycle	WiSe
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC
Literature	Pfeifer, T.: Qualitätsmanagement: Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität: Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008

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.

Course L0176: Reliability in I	Engineering Dynamics
	Lecture
Hrs/wk	
СР	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min.
scale	
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
	Method for calculation and testing of reliability of dynamic machine systems Modeling System identification Simulation Processing of measurement data Damage accumulation Test planning and execution
Literature	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4 Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737 Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936. VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412

Course L1303: Reliability in Engineering Dynamics	
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1224: Selec	ted Topics of Mechatronics (Alternative B: 6 LP)		
Courses			
Title	Тур	Hrs/wk	СР
Applied Automation (L1592)	Project-/problem-based Learning	3	3
Development Management for Med	chatronics (L1512) Lecture	2	3
Fatigue & Damage Tolerance (L03)	10) Lecture	2	3
ndustry 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
Six Sigma (L1130)	Lecture	2	3
Applied Dynamics (L1630)	Lecture	2	3
Reliability in Engineering Dynamics	s (L0176) Lecture	2	2
Reliability in Engineering Dynamics	s (L1303) Recitation Section (small)	1	2
Module Responsible	Prof. Uwe Weltin		
Admission Requirements	None		
Recommended Previous	None		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	Students are able to express their extended knowledge and discuss the connection of dareas of mechatronics Students are qualified to connect different special fields with each other	ifferent specia	l fields or applicati
Skills	 Students can 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 develop own solution approaches 		
Personal Competence			
Social Competence	None		
Autonomy			
	Students are able to develop their knowledge and skills by autonomous election of cours	es.	
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		

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
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 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	Dr. Johannes Nicolas Gebhardt, Dr. Daniel Steffen
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: Microcontrolle	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
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	
scale	
Lecturer	Prof. Hoc Khiem Trieu
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, SU8, rapid prototyping)
	Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile;
	modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer
	mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer)
	Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor:
	piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate
	sensor: operating principle and fabrication process)
	Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive
	sensors: magneto resistance, AMR and GMR, fluxgate magnetometer)
	 Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas
	sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor,
	Clark electrode, enzyme electrode, DNA chip)
	Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators.
	DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic
	micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a-
	 chip, microanalytics) MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system,
	stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant
	for spinal cord regeneration)
	 Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling:
	multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub
	relationship)
	System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding.
	TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding
	and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
	Al Cabusaingay, Labubuah Milyanyatambahnik Oldanbayya Vadag 2000
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	C. Carlach, M. Dätzak Introduction to microcustom technology, Wiley, 2009
	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
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	- 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:	
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 L1130: Six Sigma		
Тур	ecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
Content	Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC	
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008	

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	 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.

Course L0176: Reliability in I	Engineering Dynamics	
	Lecture	
Hrs/wk		
СР		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 min.	
scale		
Lecturer	Prof. Uwe Weltin	
Language	EN	
Cycle	SoSe	
	Method for calculation and testing of reliability of dynamic machine systems Modeling System identification Simulation Processing of measurement data Damage accumulation Test planning and execution	
Literature	Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4 Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737 Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936. VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412	

Course L1303: Reliability in Engineering Dynamics	
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Uwe Weltin
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1269: Lab C	yber-Physical Systems
Courses	
Title Lab Cyber-Physical Systems (L1740	Typ Hrs/wk CP Project-/problem-based Learning 4 6
Module Responsible	Prof. Heiko Falk
Admission Requirements	None
Recommended Previous	Module "Embedded Systems"
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence Knowledge	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.
Skills	After successful attendance of the lab, students are able to develop simple CPS. They understand the interdependencies between a CPS and its surrounding processes which stem from the fact that a CPS interacts with the environment via sensors, A/D converters, digital processors, D/A converters and actors. The lab enables students to compare modelling approaches, to evaluate their advantages and limitations, and to decide which technique to use for a concrete task. They will be able to apply these techniques to practical problems. They obtain first experiences in hardware-related software development, in industry-relevant specification 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	
	Written elaboration
Examination duration and scale	Execution and documentation of all lab experiments
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory
Following Curricula	Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory
	Computer Science: Specialisation II. Mathematics and Engineering Science: 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
	Computational Science and Engineering: Specialisation Computer Science: Elective Compulsory
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
	Mechatronics: Specialisation System Design: Elective Compulsory
	Mechatronics: Technical Complementary Course: Elective Compulsory

Course L1740: Lab Cyber-Physical 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			
Product Francisco	0. 200 0			
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 reach	ned the following learning results		
Professional Competence				
Knowledge	Students can explain the difference betwee	n validation of a control lop in simulation	n and experimental v	validation
Personal Competence Social Competence Autonomy	 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 experiments and document the results 			
Washing die Hauss	Students can independently carry out simul	-	trol loops	
Workload in Hours	, , , , ,	= 4Z		
Credit points Course achievement				
Examination				
Examination duration and				
scale	_			
	Electrical Engineering: Specialisation Control and I	Power Systems Engineering: Elective Co.	mnulsory	
Following Curricula			тразогу	
rollowing Curricula	, , , , , , , , , , , , , , , , , , , ,			
	Mechatronics: Specialisation System Design: Elect			
	Theoretical Mechanical Engineering: Core Qualifica		wa 4	
	Theoretical Mechanical Engineering: Technical Cor	inplementary Course: Elective Compulso	ту	

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

Course L1834: Control Lab VII	
Тур	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, Adwait Datar, Patrick Göttsch
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	Course L1743: Advanced Topics in Vibration			
Тур	Project-/problem-based Learning			
Hrs/wk	4			
СР	6			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Lecturer	Prof. Norbert Hoffmann, Merten Tiedemann, Sebastian Kruse			
Language	DE/EN			
Cycle	SoSe			
Content	Research Topics in Vibrations.			
Literature	Aktuelle Veröffentlichungen			

Module 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 theory and design				
Educational Objectives	After taking part successfully, students	s have reached the following learning results			
Professional Competence					
Knowledge	Students can explain humanoid	robots			
	· '	ontrol concepts for different tasks in humanoid ro	hotics		
	- Students ream to apply basic ec	meror concepts for university tasks in numerical re	botics.		
Skills	Students acquire knowledge ab	out selected aspects of humanoid robotics, based	d on specified literature		
	· -	results and present them to the participants	a on speemed meracare		
	Students practice to prepare an				
Personal Competence					
Social Competence	Students are capable of develop	ping solutions in interdisciplinary teams and pres	ent them		
	 They are able to provide approp 	priate feedback and handle constructive criticism	of their own results		
4					
Autonomy	 Students evaluate advantages 	and drawbacks of different forms of presenta	tion for specific tasks	and select the bes	
	solution				
	Students familiarize themselve.	• 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 Tin	ne in Lecture 28			
Credit points	2				
Course achievement	None				
Examination	Presentation				
Examination duration and	30 min				
scale					
Assignment for the	Mechatronics: Specialisation Intelligen	t Systems and Robotics: Elective Compulsory			
Following Curricula	Mechatronics: Specialisation System D	esign: Elective Compulsory			
		Artificial Organs and Regenerative Medicine: Ele			
		Implants and Endoprostheses: Elective Compuls			
		Medical Technology and Control Theory: Elective			
		Management and Business Administration: Elec			
		echnical Complementary Course: Elective Compu			
	Theoretical Mechanical Engineering: S	pecialisation Robotics and Computer Science: Ele	ective Compulsory		

Course L0663: Humanoid Ro	ourse 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).			

fication (L0660) Prof. Herbert Werner None	Typ Lecture	Hrs/wk 2	СР
Prof. Herbert Werner None			СР
Prof. Herbert Werner None			
None			3
Classical control (fraguancy respons			
State space methodsDiscrete-time systemsLinear algebra, singular value decon	nposition		
After taking part successfully, students have	ve reached the following learning results		
nonlinear model structures They can explain how multilayer per They can explain how an approxima They can explain the idea of subspa Students are capable of applying t models for dynamic systems They are capable of implementing a They are capable of applying subspa They are capable of applying subspa They can do the above using standa	receptron networks are used to model nonlinea te predictive control scheme can be based on ce identification and its relation to Kalman rea the predicition error method to the experime nonlinear predictive control scheme based or ace algorithms to the experimental identification rd software tools (including the Matlab Syster	r dynamics In neural network models alisation theory ental identification of li In a neural network mod ion of linear models for In Identification Toolbox	near and nonlinear el dynamic systems)
solve given problems.			
Independent Study Time 62, Study Time in	Lecture 28		
3			
None			
Oral exam			
30 min			
		Compulsory	
Mechatronics: Specialisation System Desig Biomedical Engineering: Specialisation Arti Biomedical Engineering: Specialisation Imp Biomedical Engineering: Specialisation Mec Biomedical Engineering: Specialisation Mar Theoretical Mechanical Engineering: Techn	n: Elective Compulsory ficial Organs and Regenerative Medicine: Elec slants and Endoprostheses: Elective Compulso dical Technology and Control Theory: Compuls nagement and Business Administration: Electi ical Complementary Course: Elective Compuls	ory sory ve Compulsory	
	State space methods Discrete-time systems Linear algebra, singular value decone Basic knowledge about stochastic properties of the space of the spa	 Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic processes After taking part successfully, students have reached the following learning results Students can explain the general framework of the prediction error method an nonlinear model structures They can explain how multilayer perceptron networks are used to model nonlinea They can explain how an approximate predictive control scheme can be based on They can explain the idea of subspace identification and its relation to Kalman reading and the idea of subspace identification and its relation to Kalman reading and the idea of subspace identification and its relation to Kalman reading are capable of applying the predictive control scheme based on They are capable of implementing a nonlinear predictive control scheme based on They are capable of applying subspace algorithms to the experimental identificate They can do the above using standard software tools (including the Matlab System) Students can work in mixed groups on specific problems to arrive at joint solutions. Students are able to find required information in sources provided (lecture notes, literat solve given problems. Independent Study Time 62, Study Time in Lecture 28 3 None Oral exam 30 min Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsomedical Engineering: Specialisation Management and Business Administration: Electi	State space methods Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic processes After taking part successfully, students have reached the following learning results Students can explain the general framework of the prediction error method and its application to a v 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 prediction error method to the experimental identification of line models for dynamic systems They are capable of implementing a nonlinear predictive control scheme based on a neural network model or They are capable of applying subspace algorithms to the experimental identification of linear models for They are capable of applying subspace algorithms to the experimental identification of linear models for They are capable of applying subspace algorithms to the experimental identification of linear models for They are capable of applying subspace algorithms to the experimental identification Tolibox Students can work in mixed groups on specific problems to arrive at joint solutions. Students are able to find required information in sources provided (lecture notes, literature, software document solve given problems. Independent Study Time 62, Study Time in Lecture 28 3 None Oral exam They can do the above using specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation Power Systems and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoreti

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 		

ol Lab A			
	Typ Practical Course Practical Course Practical Course Practical Course	Hrs/wk 1 1 1	CP 1 1 1 1
Prof. Herbert Werner			
None			
LQG control H2 and H-infinity optimal control	rol		
After taking part successfully, students have r	eached the following learning results		
Students can explain the difference between validation of a control lop in simulation and experimental validation			
 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 o LPV gain-scheduled controllers 			
Students can work in teams to conduct	experiments and document the results		
Students can independently carry out s	imulation studies to design and validate con	trol loops	
Independent Study Time 64, Study Time in Le	cture 56		
4			
None			
Electrical Engineering: Specialisation Control a	and Power Systems Engineering: Elective Co	mpulsory	
Mechatronics: Specialisation System Design: E	Elective Compulsory	-	
Mechatronics: Specialisation Intelligent System	ns and Robotics: Elective Compulsory		
	Prof. Herbert Werner None State space methods LQG control H2 and H-infinity optimal control uncertain plant models and robust cont LPV control After taking part successfully, students have r Students can explain the difference bet Students are capable of applying bas dynamic model that can be used for co They are capable of using standard so implementation of H-infinity optimal co They are capable of representing mode They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co They are capable of using standard sofic implementation of H-infinity optimal co	Prof. Herbert Werner None State space methods LQG control Hz 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 are capable of applying basic system identification tools (Matlab Syst dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for controllers They are capable of the 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 representing model uncertainty, and of designing and impleme They are capable of using standard software tools (Matlab Robust Control Toolbox) in 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 con Independent Study Time 64, Study Time in Lecture 56 Hone Written elaboration Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Communics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory	Typ Hrs/wk Practical Course 1 Pr

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

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

Course L1665: Control Lab II	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, Adwait Datar, Patrick Göttsch		
Language	EN		
Cycle	WiSe/SoSe		
Content	One of the offered experiments in control theory.		
Literature	Experiment Guides		

Course L1666: Control Lab IV	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, Adwait Datar, Patrick Göttsch		
Language	EN		
Cycle	WiSe/SoSe		
Content	One of the offered experiments in control theory.		
Literature	Experiment Guides		

Module M0924: Softw	are for Embedded Systems			
Courses				
Title		Тур	Hrs/wk	СР
Software for Embdedded Systems ((L1069)	Lecture	2	3
Software for Embdedded Systems (L1070)	Recitation Section (small)	3	3
Module Responsible	Prof. Bernd-Christian Renner			
Admission Requirements	None			
Recommended Previous	Good knowledge and experience in programm	sing language C		
Knowledge	Basis knowledge in software engineering	ing language C		
	Basic understanding of assembly language			
	- basic anacistanding of assembly language			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	Students know the basic principles and procedures	of software engineering for embedded sy	stems. They are	able to describe the
	usage and pros of event based programming u	sing interrupts. They know the compo	nents and func	tions of a concrete
	microcontroller. The participants explain requirement	nts of real time systems. They know at I	east three sched	duling algorithms for
	real time operating systems including their pros and	cons.		
Skills	Students build interrupt-based programs for a con-	crete microcontroller. They build and use	e a preemptive	scheduler. They use
	peripheral components (timer, ADC, EEPROM) to	realize complex tasks for embedded s	systems. To inte	rface with external
	components they utilize serial protocols.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 110, Study Time in Lecture	70		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Computer Science: Specialisation I. Computer and Science	oftware Engineering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Information and	d Communication Systems: Elective Comp	oulsory	
	Information and Communication Systems: Specia	lisation Secure and Dependable IT Sy	stems, Focus S	oftware and Signal
	Processing: Elective Compulsory			
	Information and Communication Systems: Specialisa	•		mpulsory
	International Management and Engineering: Speciali		Compulsory	
	Mechatronics: Technical Complementary Course: Ele			
	Mechatronics: Specialisation Intelligent Systems and	Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective			
	Microelectronics and Microsystems: Specialisation Er			
	Microelectronics and Microsystems: Specialisation Er	nbedded Systems: Elective Compulsory		

Course L1069: Software for I	Embdedded Systems			
Тур	ecture			
Hrs/wk	2			
СР				
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	ecitation Section (small)		
Hrs/wk	3		
СР	3		
Workload in Hours	dependent Study Time 48, Study Time in Lecture 42		
Lecturer	Prof. Bernd-Christian Renner		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Fitle	11003)	Тур	Hrs/wk	CP
Compilers for Embedded Systems (Compilers for Embedded Systems (Lecture Project-/problem-based Le	3 earning 1	4 2
Module Responsible		Troject/problem basea 20	arining 1	
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	The relevance of embedded systems increas embedded processors grows continuously do of embedded systems, highly optimized ar impose high demands on compilers which has the students are able • to illustrate the structure and organization.	ue to its lower costs and higher flexibility. Build application-specific processors are deplored to generate code of highest quality. After	ecause of the partice byed. Such highly s	ular application are pecialized processo
		e representations of various abstraction leve	ls, and	
	The high demands on compilers for embed particular,	dded systems make effective code optimiz	ations mandatory. T	he students learn
	 which kinds of optimizations are applicent to how the translation from source codes which kinds of optimizations are applicent how register allocation is performed, and how memory hierarchies can be explosed. 	to assembly code is performed, cable at the assembly code level, and		
	Since compilers for embedded systems ofter energy dissipation, code size), the students I			
Skills	Skills After successful completion of the course, students shall be able to translate high-level program code into machin be enabled to assess which kind of code optimization should be applied most effectively at which abstraction level assembly code) within a compiler.			
	While attending the labs, the students will lea	arn to implement a fully functional compiler	including optimizatio	ins.
Personal Competence				
Social Competence	Students are able to solve similar problems a	lone 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	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	Computer Science: Specialisation I. Compute	r and Software Engineering: Elective Compu	Isory	
Following Curricula	Electrical Engineering: Specialisation Informa		-	
-	Aircraft Systems Engineering: Specialisation	·	-	
	Mechatronics: Specialisation Intelligent Syste	ems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design:	' '		
	Mechatronics: Technical Complementary Cou	• •		
	Theoretical Mechanical Engineering: Technical	al Complementary Course: Elective Compuls	ory	
	Theoretical Mechanical Engineering: Specialis	sation Robotics and Computer Science: Elect	ive Compulsory	

Course L1692: Compilers for	Embedded Systems				
Тур	Lecture				
Hrs/wk					
СР					
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	oject-/problem-based Learning			
Hrs/wk	1			
СР	2			
Workload in Hours	dependent 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 (L065)	8)	Lecture	2	3			
Optimal and Robust Control (L065)	9)	Recitation Section (small)	2	3			
Module Responsible	Prof. Herbert Werner						
Admission Requirements	None						
Recommended Previous	Classical control (frequency response, root locu	16)					
Knowledge	State space methods	15)					
	Linear algebra, singular value decomposition						
Educational Objectives		the following learning results					
Professional Competence							
Knowledge	Students can explain the significance of the ma	atrix Riccati equation for the solution of	LQ problems.				
	They can explain the duality between optimal s	state feedback and optimal state estima	tion.				
	They can explain how the H2 and H-infinity nor	ms are used to represent stability and p	erformance cons	traints.			
	They can explain how an LQG design problem of the control of						
	They can explain how model uncertainty can be a seed as the area!						
	 They can explain how - based on the small ga an uncertain plant. 	in theorem - a robust controller can gu	arantee Stability	and performance for			
	They understand how analysis and synthesis co	onditions on feedback loops can be repr	esented as linear	matrix inequalities.			
Skills	 Students are capable of designing and tuning L 	.QG controllers for multivariable plant m	odels.				
	They are capable of representing a H2 or H-infi	inity design problem in the form of a ge	neralized plant, a	and of using standard			
	software tools for solving it.						
	They are capable of translating time and frequency.	uency domain specifications for control	loops into const	raints on closed-loop			
	sensitivity functions, and of carrying out a mixe						
	They are capable of constructing an LFT unce	ertainty model for an uncertain system	, and of designing	ng a mixed-objective			
	robust controller. They are capable of formulating analysis and s	cynthosis conditions as linear matrix inc	gualities (LMI) a	nd of using standard			
	LMI-solvers for solving them.	synthesis conditions as inlear matrix me	qualities (LMI), a	nd or using standard			
		They can carry out all of the above using standard software tools (Matlab robust control toolbox).					
Personal Competence							
Social Competence Autonomy	Students can work in small groups on specific problems to arrive at joint solutions. Students are able to find required information in sources provided (lecture notes, literature, software decumentation) and use it to						
Autonomy	Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.						
	Solve given problems.						
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	56					
Credit points	6						
Course achievement	None						
Examination	Oral exam						
Examination duration and	30 min						
scale							
Assignment for the	Electrical Engineering: Specialisation Control and Pow	er Systems Engineering: Elective Comp	ulsory				
Following Curricula			-				
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory						
	Mechatronics: Specialisation Intelligent Systems and I	Robotics: Elective Compulsory					
	Mechatronics: Specialisation System Design: Elective						
	Biomedical Engineering: Specialisation Artificial Organ		Compulsory				
	Biomedical Engineering: Specialisation Implants and E		aulaam:				
	Biomedical Engineering: Specialisation Medical Techn Biomedical Engineering: Specialisation Management a		-				
	Product Development, Materials and Production: Spec						
	Product Development, Materials and Production: Spec						
	Product Development, Materials and Production: Spec						
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory						
	Theoretical Mechanical Engineering: Core Qualification	n: 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	of. 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	ecitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	ndependent 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 M1400: Desig	ın of Dependable	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	y, Availability, Maintainabilit	ty, Safety and Secu	ırity.		
	Knowledge about appro	oaches for designing de	pendable systems	, e.g.,				
	Structural solution	ons like modular redund	lancy					
	Algorithmic solut	tions like handling byza	ntine faults or che	ckpointing				
	Knowledge about meth	ods for the analysis of	dependable systen	ns				
Skills	Ability to implement de	pendable systems usin	g the above appro	aches.				
	Ability to analyzs the de	Ability to analyzs the dependability of systems using the above methods for analysis.						
Personal Competence								
Social Competence	Students							
	discuss relevant	topics in class and						
	 present their sol 	utions orally.						
Autonomy	additional solution strat		pendently learn in	-depth relations between c	oncepts explained	in the lecture and		
Workload in Hours			actura E6					
Credit points		le 124, Study Tille III L	ecture 56					
Course achievement		Form	Description					
Course acmevement		Subject theoretical	•	einer Aufgabe ist Zuslassun	gsvoraussetzung 1	ür die Prüfung. Die		
		practical work	Aufgabe wird	in Vorlesung und Übung def	finiert.			
Examination	Oral exam							
Examination duration and	30 min							
scale								
Assignment for the	Computer Science: Spe	cialisation I. Computer	and Software Engi	neering: Elective Compulsor	у			
Following Curricula	Computational Science	and Engineering: Spec	ialisation I. Compu	ter Science: Elective Compu	Isory			
	Information and Comm	unication Systems: Spe	cialisation Secure	and Dependable IT Systems	: Elective Compuls	ory		
	Mechatronics: Specialis	Mechatronics: Specialisation System Design: Elective Compulsory						
	Microelectronics and M	icrosystems: Specialisa	icroelectronics 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 Applicability
	Availability Maintainability
	Safety
	• Security
	This makes dependability a core aspect that has to be considered early in system design, no matter whether software, embedded systems or full scale cyber-physical systems are considered. Contents
	The module introduces the basic concepts for the design and the analysis of dependable systems. Design examples for getting practical hands-on-experience in dependable design techniques. The module focuses towards embedded systems. The following topics are covered:
	Modelling Fault Tolerance Design Concepts Analysis Techniques
Literature	

ourse L2001: Designing Dependable Systems		
	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	

Module M0565: Mech	atronic Systems					
Courses						
Title Typ Hrs/wk CI					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	Prof. Uwe Weltin					
Admission Requirements	None					
Recommended Previous	Fundamentals of mechanics, electromec	hanics and control theo	ry			
Knowledge						
Educational Objectives	After taking part successfully, students h	ave reached the follow	ing learning results			
Professional Competence						
Knowledge	Students are able to describe methods	and calculations to de	sign, model, simulate and optim	ize mechatron	ic systems and can	
	repeat methods to verify and validate me	odels.				
Skills	Students are able to plan and execute	mechatronic experime	nts. Students are able to model	mechatronic s	systems and derive	
	simulations and optimizations.					
Personal Competence						
Social Competence	Students are able to work goal-oriented	Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities and define task within				
,	the team.	, , , , , , , , , , , , , , , , , , ,	3			
Autonomy	Students are able to solve individually ex	ercises related to this l	ecture with instructional direction	٦.		
	Students are able to plan, execute and s	ummarize a mechatron	ic experiment.			
Workload in Hours	Independent Study Time 110, Study Tim	e in Lecture 70				
Credit points						
Course achievement	Compulsory Bonus Form	Description				
	Yes None Subject theore	ical and				
	practical work					
Examination						
Examination duration and	90 min					
scale						
Assignment for the	Electrical Engineering: Specialisation Cor	ntrol and Power System	s Engineering: Elective Compulso	ry		
Following Curricula	Aircraft Systems Engineering: Specialisa	ion Avionic Systems: E	lective Compulsory			
	Aircraft Systems Engineering: Specialisa	ion Aircraft Systems: E	lective Compulsory			
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					
	Mechatronics: Specialisation System Des	ign: Elective Compulso	ry			

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	Prof. Uwe Weltin
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

ourse L1300: Electro- and Contromechanics	
Тур	Recitation Section (small)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Uwe Weltin
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	Prof. Uwe Weltin
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

Courses				
Title		Тур	Hrs/wk	СР
	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Module Responsible	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	3,,	3 3		
Knowledge	Students can explain the basic principles, relationships	s, and methods for the design of wa	veguides and an	tennas as well as o
	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			
	- Steady-state sinusoidal description of electromagnetic	fields and waves		
	- Useful microwave network parameters			
	- Transmission lines and basic results from transmission			
	- Plane wave propagation, superposition, reflection and	refraction		
	 General theory of waveguides Most important types of waveguides and their properti 	ne.		
	- Radiation and basic antenna parameters	= 5		
	 Most important types of antennas and their properties 			
	Numerical techniques and CAD tools for waveguide and	d antenna design		
	- Fundamentals of Electromagnetic Compatibility	a unicima design		
	- Coupling mechanisms and countermeasures			
	- Shielding, grounding, filtering			
	- Standards and regulations			
	- EMC measurement techniques			
Skills	Students know how to apply various methods and mod			
	able to assess and qualify their basic electromagne		lts and strategie	es from the field o
	Electromagnetic Compatibilty 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 i
,	English (e.g. during small group exercises).	3 . ,	·	,
Autonomy	Students are capable to gather information from sub			
	context of the lecture. They are able to make a connect			
	other lectures (e.g. theory of electromagnetic fields, fur	idamentals of electrical engineering /	pnysics). They o	an discuss technica
	problems and physical effects in English.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and	45 min			
scale				
Assignment for the	General Engineering Science (German program, 7 seme	- ·	ering: Elective Co	mpulsory
Following Curricula	Electrical Engineering: Core Qualification: Elective Comp	•		
	Aircraft Systems Engineering: Specialisation Air Transpo			
	Aircraft Systems Engineering: Specialisation Cabin Syste			
	General Engineering Science (English program, 7 semes		rıng: Elective Con	npulsory
	Mechatronics: Specialisation System Design: Elective Co	mpulsory		

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	Notic			
Knowledge	Calculus Stochastics			
Educational Objectives	After taking part successfully, students have reach	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 and compare the different goals of those techniques.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours		e 56		
Credit points	6			
Course achievement				
Examination duration and	90 minutes			
scale				
Assignment for the	Computer Science: Specialisation II: Intelligence En			
Following Curricula	International Management and Engineering: Specia		ective Compulsory	
	Mechatronics: Technical Complementary Course: E			
	Mechatronics: Specialisation Intelligent Systems an Mechatronics: Specialisation System Design: Electiv	• •		
	Theoretical Mechanical Engineering: Technical Com		orv	
	Theoretical Mechanical Engineering: Specialisation		•	

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

urse 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 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 recommende	d.		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the f	ollowing learning results		
Professional Competence				
Knowledge	Students are able to			
	+ give an overview of the different nonlinear phenomena i	n structural mechanics.		
	+ explain the mechanical background of nonlinear phenon	nena in structural mechanics.		
	+ to specify problems of nonlinear structural analysis, to	identify them in a given situation	and to explain the	ir mathematical and
	mechanical background.			
Skills	Students are able to			
SKIIIS	+ model nonlinear structural problems.			
	+ select for a given nonlinear structural problem a suitable	e computational procedure		
	+ apply finite element procedures for nonlinear structural			
	+ critically verify and judge results of nonlinear finite elem			
	+ to transfer their knowledge of nonlinear solution procedu			
	The diameter and who meage of norminear solution process.	ares to new prostems.		
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous groups and to docume	ent the corresponding results.		
	+ share new knowledge with group members.			
Autonomy	Students are able to			
	+ acquire independently knowledge to solve complex prob	olems.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Civil Engineering: Specialisation Structural Engineering: Ele	ective Compulsory		
Following Curricula	International Management and Engineering: Specialisation	II. Civil Engineering: Elective Con	npulsory	
	Materials Science: Specialisation Modeling: Elective Compu	ulsory		
	Mechatronics: Specialisation System Design: Elective Com	pulsory		
	Product Development, Materials and Production: Core Qua	lification: Elective Compulsory		
	Naval Architecture and Ocean Engineering: Core Qualificat	ion: Elective Compulsory		
	Ship and Offshore Technology: Core Qualification: Elective	Compulsory		
	Theoretical Mechanical Engineering: Specialisation Simulat	tion Technology: Elective Compuls	sory	

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

Course L0279: Nonlinear 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: Microsystem Engineering						
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 I	Cusserow				
Admission Requirements	None					
Recommended Previous	Basic courses in physics, mathematics and electric engineering					
Knowledge						
Educational Objectives	After taking part successfully, students have reached the following learning results					
Professional Competence						
Knowledge	The students know a actuators.	bout the most impo	ortant technologies and	d materials of MEMS as well as	their applicat	cions in sensors and
Skills	Students are able to microsystems.	analyze and desc	ribe the functional be	haviour of MEMS components	and to evalua	ate the potential of
Personal Competence						
Social Competence	Students are able to s	solve specific proble	ms alone or in a group	and to present the results accord	dingly.	
Autonomy	Students are able to other fields.	acquire particular kı	nowledge using special	ized literature and to integrate a	and associate	this knowledge with
Workload in Hours	Independent Study Ti	me 124, Study Time	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:	Compulsory			
Following Curricula	International Manage	ment and Engineering	ng: Specialisation II. Ele	ctrical Engineering: Elective Con	npulsory	
	International Manage	ment and Engineering	ng: Specialisation II. Me	chatronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory					
	Mechatronics: Specialisation System Design: Elective Compulsory					
	Microelectronics and Microsystems: Core Qualification: Elective Compulsory					
	Theoretical Mechanic	al Engineering: Spec	ialisation Bio- and Med	ical Technology: Elective Compu	Isory	

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

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

Module M0806: Techi	nical Acoustics II (Room Acoustic	s, Computational 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, Psycho Acoustics)				
Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics)				
	Mathematics I, II, III (in particular differential eq	uations)			
Educational Objectives	After taking part successfully, students have rea	ached the following learning results			
Professional Competence					
Knowledge	The students possess an in-depth knowledge in acoustics regarding room acoustics and computational methods and are able to				
	give an overview of the corresponding theoretic	al and methodical basis.			
Skills	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding computational methods and procedures treated within the module.				
Personal Competence					
Social Competence	Students can work in small groups on specific p	roblems to arrive at joint solutions.			
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possibl conflicting issues and limitations can be identified and the results are critically scrutinized.				
Workload in Hours	Independent Study Time 124, Study Time in Led	cture 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	n: Elective Compulsory			
Following Curricula	Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory				
	Mechatronics: Specialisation System Design: Ele	ective Compulsory			
	Product Development, Materials and Production	: Core Qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisat	ion Product Development and Production: Ele	ctive Compulsory		

Course L0519: Technical Acoustics II (Room Acoustics, Computational Methods)			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Otto von Estorff		
Language	EN		
Cycle	WiSe		
Content	- Room acoustics		
	- Sound absorber		
	- Standard computations		
	- Statistical Energy Approaches		
	- Finite Element Methods		
	- Boundary Element Methods		
	- Geometrical acoustics		
	- Special formulations		
	- Practical applications		
	- Hands-on Sessions: Programming of elements (Matlab)		
Literature	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin		
Literature	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	

Admission in Control (1960) Medical Responsible (Incident (1960)) Medical Responsible (Incident (1960)) Medical Responsible (Incident (1960)) Modula Responsible (Incident (1960))	Module M0832: Adva	nced Topics in Control				
Admission in Control (1960) Medical Responsible (Incident (1960)) Medical Responsible (Incident (1960)) Medical Responsible (Incident (1960)) Modula Responsible (Incident (1960))	Courses					
Value Comment Commen	Title		Typ	Hrs/wk	СР	
Administration Requirements Administration Requirements Administration Requirements Accommended Previous Educational Objectives Educational Objectives Effects and Objectives Educational Objectives Administration (Supplementation of Supplementation of Supplementation) Students can explain the adventages and silentromings of the classical gain scheduling approach They can explain the expresentation of nonlinear systems in the form of quasi-VP systems Students can explain the adventages and silentromings of the classical gain scheduling approach They can explain the adventages and silentromings of the classical gain scheduling approach They can explain the adventages and silentromings of the classical gain scheduling approach They can explain the adventages and silentromings of the classical gain scheduling approach They can explain the adventages and silentromings of the classical gain scheduling approach They can explain the adventages and silentromings of the classical gain scheduling approach They can explain the adventages and silentromings of the classical gain scheduling approach They can explain the adventages and silentromings of the classical gain scheduling approach They can explain the adventages and silentromings of the classical gain scheduling approach They can explain the adventages and silentromings of the classical gain scheduling approach They are familiar with public gain of silentromines They are familiar with public gain of silentromines and several public gain and systems of the basic synthesis conditions for these readed structures They can explain the adventages and silentromines of patiently invariant distributed systems that are discretized according to an actuatorizensor array They can explain for nutling the extension of the bounded real lemma to such distributed systems that are discretized according to an actuatorizensor array They can explain in nutling the extension of the bounded real lemma to such distributed systems that are adventaged to constructing DVP models	Advanced Topics in Control (L0661)				
Admission Requirements Nove Recommended Provious Landing or production of the Casas Control of Provious Landing Services (India Provious Landing Services) Recommended Provious Landing and soccessfully, students have reached the following learning results Professional Competence Activities **Sudents can explain the advantages and shortcomings of the classical gain scheduling approach **They can explain the properation of nonlinear systems in the form of quasi-LPV systems **They can explain the properation of nonlinear systems in the form of quasi-LPV systems **They are familiar with polytopic and LTT representations of LPV systems and some of the basic synthesis schiniques associated with each of these model structures **Sudents can explain the convergence properties of first order consensus protocols **They can explain the convergence properties of first order consensus protocols **They can explain the convergence properties of first order consensus protocols **They can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuator/bensor array **They can explain the odding the declaration of spatially invariant distributed systems and the associated systems and some of the basic systems and the associated systems conditions for declaration control loops invalving either LTI or LPV agrammon, and an actuator/bensor array **They can explain the objects of the state space representation of spatially invariant distributed systems and the associated systems conditions for declaration control loops invariant distributed systems and the associated systems conditions for declaration control loops invariant distributed systems and the associated systems are able to design distributed formation controllers for groups of agents with either LTI or LPV dynamics, using Hatale tools provided **Students are able to find required information in sources provided flecture notes, literature, software documentation) and use it to solve the properation and	Advanced Topics in Control (L0662)	Recitation Section (small)	2	3	
Recommended Previous Arthritory optimal control, mixed-sensibility design, linear matrix inequalities Roweldge Routestional Objectives After taking part successfully, students have reached the following learning results Professional Competence Roweldge	Module Responsible	Prof. Herbert Werner				
## After taking part successfully, students have reached the following learning results Professional Competence Account of the part of t	Admission Requirements	None				
### After taking part successfully, students have reached the following learning results Professional Competence **Consideral Professional Competence **Students can explain the advantages and shortcomings of the classical gain scheduling approach **They can explain the representation of nonlinear systems in the form of quasi-LPV systems **They can explain how gridding scheiniques can be used to solve analysis and synthesis problems for LPV systems **They can explain how gridding scheiniques can be used to solve analysis and synthesis problems for LPV systems **They can explain how graph theoretic concepts are used to represent the communication topology of multilagent systems **Students can explain how graph theoretic concepts are used to represent the communication topology of multilagent systems **They can explain the convergence properties of first order consensus protocols **They can explain the convergence properties of first order consensus protocols **They can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuator/sensor array **They can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuator/sensor array **Students can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuator/sensor array **Students are able to design distributed formation controllers for formation control loops involving either LTI or LPV dynamics, using scheduled controllers; they can do this using polytopic. LTI or general LPV models **Students are able to design distributed formation controllers for spatially interconnected systems, using the Matlab MO-boolbox **Students are able to design distributed formation in sources provided (lecture notes, literature, software documentation) and use it to solve a schewament lone **Students are able to design distributed information in sources provided (lecture note	Recommended Previous	H-infinity optimal control, mixed-sensitivity design, line	ar matrix inequalities			
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Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory						
Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory			-			

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

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: Methi	ods of Integrated Product Develo	pment			
Courses					
Title		Тур	Hrs/wk	СР	
Integrated Product Development II		Lecture	3	3	
Integrated Product Development II		Project-/problem-based Learning	2	3	
Module Responsible					
Admission Requirements	None				
Recommended Previous	Basic knowledge of Integrated product developr	ment and applying CAE systems			
Knowledge					
Educational Objectives	After taking part successfully, students have rea	ached the following learning results			
Professional Competence					
Knowledge	After passing the module students are able to:				
	explain technical terms of design method	lology,			
	describe essential elements of construction				
	describe current problems and the currer	nt state of research of integrated product develo	pment.		
Skills	After passing the module students are able to:				
	select and apply proper construction me	ethods for non-standardized solutions of probler	ns as well as	adapt new bounda	
	conditions,				
	solve product development problems with	h the assistance of a workshop based approach,			
	choose and execute appropriate moderation techniques.				
Personal Competence	After a continuation of the second of the se				
Social Competence	After passing the module students are able to:				
	prepare and lead team meetings and moderation processes,				
	work in teams on complex tasks,				
	 represent problems and solutions and ad 	vance ideas.			
Autonomou	After passing the passing students are able to				
Autonomy	After passing the module students are able to:				
	 give a structured feedback and accept a 	give a structured feedback and accept a critical feedback,			
	 implement the accepted feedback autonometers 	omous.			
Workload in Hours	Indopondent Study Time 110, Study Time in Loc	eturo 70			
Credit points		cuie 70			
Course achievement					
Examination	Oral exam				
Examination duration and scale	30 Minuten				
	Aircraft Systems Engineering, Specialisation Cal	nin Systems: Elective Compulsory			
Assignment for the					
Following Curricula	Aircraft Systems Engineering: Specialisation Air Aircraft Systems Engineering: Core Qualification				
		i: Elective Compuisory ecialisation II. Product Development and Product	ion: Elective C	ompulsory	
	Mechatronics: Specialisation System Design: Ele	·	ion. Liective Ci	ompuisory	
	1	: Specialisation Product Development: Compulso	rv		
	, and the second	: Specialisation Production: Elective Compulsory	' 3		
	Product Development, Materials and Production				
	, and the second	ion Product Development and Production: Elective	e Compulsory		
		I Lace Development and Froduction. Election	_ copaisory		

se L1254: Integrated Pr				
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 Position			
	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.			
	Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater und			
	Trainer, Weinheim, Beltz 2007.			
	Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006.			
	Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000.			
	• Simpson, T.W., Siddique, Z., Jiao, R.J.: Product Platform and Product Family Design. Methods and Applications, New York,			
	Springer 2012			

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

Springer 2013.

Module M1173: Appli	ed 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 have reached the following	ng learning results		
Professional Competence					
Knowledge	Students can explain the statistical methods and the conditions of their use.				
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results				
Personal Competence					
Social Competence	Team Work, joined presentation of results				
•					
Autonomy	To understand and interpret the question and solve				
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70				
Credit points	6				
Course achievement	Compulsory Bonus Form	Description			
	Yes None Writter	n elaboration			
Examination	Written exam				
Examination duration and	90 minutes, 28 questions				
scale	•				
Assignment for the	Mechanical Engineering and M	lanagement: Specialisation Manage	ement: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation S	ystem Design: Elective Compulsory	, ,		
-	·	ntelligent Systems and Robotics: El			
	Biomedical Engineering: Core				
	Product Development, Materia	als and Production: Core Qualification	on: Elective Compulsory		
	Theoretical Mechanical Engine	eering: Specialisation Bio- and Medi	cal Technology: Elective Compu	Isory	

Course I 1504 - Aveille d Chable	Mar.		
Course L1584: Applied Statis			
	ecture		
Hrs/wk			
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Michael Morlock		
Language	DE/EN		
Cycle	WiSe		
Content	The goal is to introduce students to the basic statistical methods and their application to simple problems. The topics include:		
	Chi square test		
	Simple regression and correlation		
	Multiple regression and correlation		
	One way analysis of variance		
	Two way analysis of variance		
	Discriminant analysis		
	Analysis of categorial data		
	Chossing the appropriate statistical method		
	Determining critical sample sizes		
Literature	Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University, Lawrence L. Kupper		
	University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University,		
	Published by Duxbury Press, CB © 1998, ISBN/ISSN: 0-534-20910-6		

Course L1586: Applied Statis	stics
Тур	Project-/problem-based Learning
Hrs/wk	2
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 Optimization of dynamical systems		Typ Lecture Lecture	Hrs/wk 2 2	CP 3
Module Responsible	Prof. Robert Seifried	Eccture		
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 following learning results		
Professional Competence				
Knowledge	Students demonstrate basic knowledge and unders multibody systems and methods for optimizing dynar			ex rigid and flexible
Skills	Students are able			
	+ to think holistically + to independently, securly and critically analyze a systems + to describe dynamics problems mathematically + to optimize dynamics problems Students are able to + solve problems in heterogeneous groups and to do Students are able to			d flexible multibody
Autonomy	Students are able to			
	+ assess their knowledge by means of exercises.			
	+ acquaint themselves with the necessary knowledg	e to solve research oriented task	rs.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement	None			<u> </u>
Examination	Oral exam			
Examination duration and	30 min			<u> </u>
scale				
Assignment for the Following Curricula	1	ctive Compulsory Systems: Elective Compulsory c Compulsory Robotics: Elective Compulsory	ory	
	Theoretical Mechanical Engineering: Core Qualification	on: 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	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, Dr. Alexander Held
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 Dynamics.			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follow	ing learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts in Wave Mechanics and to develop and research new terms and concepts.			
Skills	Students are able to apply existing methods and procesures of Wave Mechanics and to develop novel methods and procedures.			
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks individually and t	o identify and follow up novel resear	rch tasks by ther	nselves.
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 Compulso	ry		
Following Curricula	Naval Architecture and Ocean Engineering: Core Qualification: E	Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Maritime Technology	chnology: 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	Tractical course	-	-
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 reached the	following learning results		
Professional Competence Knowledge	Students can explain the difference between validations	ation of a control lop in simulation	on and experimental v	validation
Skills	Students are capable of applying basic system of dynamic model that can be used for controller synt. They are capable of using standard software too controllers They are capable of using standard software tools implementation of H-infinity optimal controllers They are capable of representing model uncertaint. They are capable of using standard software tools LPV gain-scheduled controllers	thesis Ils (Matlab Control Toolbox) for (Matlab Robust Control Toolbox) y, and of designing and implem	the design and imp) for the mixed-sensit enting a robust contro	lementation of LQG ivity design and the
Personal Competence Social Competence	Students can work in teams to conduct experiment	s and document the results		
Autonomy	Students can independently carry out simulation st	udies to design and validate co	ntrol loops	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Credit points	2			
Course achievement				
Examination				
Examination duration and scale	1			
Assignment for the	Electrical Engineering: Specialisation Control and Power S	ystems Engineering: Elective Co	ompulsory	
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robo Mechatronics: Specialisation System Design: Elective Con			

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

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

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 presental 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	pics 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 ar	d 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 Equation	ns		
	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 areas of multibody dynamics and robotics	demonstrate deeper knowledge and under	erstanding in	selected application
Skills	Students are able			
	+ to think holistically			
	+ to independently, securly and critically analyze a systems	nd optimize basic problems of the dynami	cs 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 do	cument the corresponding results and prese	ent them	
Autonomy	Students are able to			
	+ assess their knowledge by means of exercises and	projects.		
	+ acquaint themselves with the necessary knowledge	to solve research oriented tasks.		
Workload in Hours	Independent Study Time 152, Study Time in Lecture 2	28		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	ТВА			
scale				
Assignment for the	1			
Following Curricula	1			
ĺ	Theoretical Mechanical Engineering: Core Qualificatio	n: Elective Compulsory		

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

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	Analysis: partial derivatives, gradient, directi	anal dariyatiya		
Knowledge	Linear Algebra: eigenvalues, least squares so			
	Elifedi Algebra. elgerivaldes, least squares so	nution of a linear system		
Educational Objectives	After taking part successfully, students have reache	ed the following learning results		
Professional Competence				
Knowledge	Students are able to			
	 characterize and compare diffusion equation: 	S		
	explain elementary methods of image process			
	 explain methods of image segmentation and 			
	sketch and interrelate basic concepts of func	tional analysis		
Skille	Students are able to			
SKIIIS	Students are able to			
	 implement and apply elementary methods of 	image processing		
	 explain and apply modern methods of image 	processing		
Personal Competence				
	Students are able to work together in heterog	eneously composed teams (i.e., teams	from different s	tudy programs and
	background knowledge) and to explain theoretical f	oundations.		
4.4				
Autonomy	Students are capable of checking their under	erstanding of complex concepts on their	own. They can spe	ecify open questions
	precisely and know where to get help in solvi	ng them.		
	 Students have developed sufficient persiste 	nce to be able to work for longer period	ds in a goal-orient	ed manner on hard
	problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture	e 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Bioprocess Engineering: Specialisation A - General E	Bioprocess Engineering: Elective Compuls	ory	
Following Curricula	Computer Science: Specialisation III. Mathematics: I	Elective Compulsory		
	Computational Science and Engineering: Specialisat			
	Interdisciplinary Mathematics: Specialisation Compu		Compulsory	
	Mechatronics: Technical Complementary Course: El	, ,		
	Mechatronics: Specialisation System Design: Electiv			
	Mechatronics: Specialisation Intelligent Systems and	• • •		
	Technomathematics: Specialisation I. Mathematics:	• •	Compulsor	
	Theoretical Mechanical Engineering: Specialisation Process Engineering: Specialisation Process Engineering:		Compulsory	
	Process Engineering: Specialisation Process Engineer	ering. 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

ourses				
itle		Тур	Hrs/wk	СР
tegrated Circuit Design (L0691)		Lecture	3	4
tegrated Circuit Design (L0998)	I	Recitation Section (small)	1	2
Module Responsible				
Admission Requirements				
Recommended Previous				
Knowledge	Knowledge in fundamentals of electrical engineering and ele	ctrical networks.		
Educational Objectives	After taking part successfully, students have reached the foll	lowing learning results		
Professional Competence Knowledge		t and diffusion current densities, n-diodes, MOS capacitors, and MC tionships and small-signal equiva behavior transistors based on cha atic and dynamic logic gates for in usumption on the device and circu analytical expression for device a	semiconductor de OSFETs using ene blent circuits of th arged carrier flow ntegrated circuits uit level	evice equations). rgy band diagrams ese devices.
Skills	Students can qualitatively construct energy band diag Students are able to qualitatively determine electr diagrams. Students can understand scientific publications from t Students can calculate the dimensions of MOS devices Students can design complex electronic circuits and a Students know procedure for optimization regarding h	ic field, carrier concentrations, he field of semiconductor devices s in dependence of the circuits pr nticipate possible problems.	and charge flow s. operties	from energy ba
Personal Competence Social Competence Autonomy	Students can team up with other experts in the field to Students are able to work by their own or in small gro Students have the ability to critically question the values.	ups for solving problems and ans ue of their contributions to workir stic manner.		istions.
	State is a specific and possible approaches	to some chancinging problems		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelectronics and Mi	crosystems Technology: Elective	Compulsory	
Following Curricula	International Management and Engineering: Specialisation II.	. Electrical Engineering: Elective	Compulsory	
-	Mechanical Engineering and Management: Specialisation Me		-	
	Mechatronics: Specialisation System Design: Elective Compu	llsory		
	Microelectronics and Microsystems: Core Qualification: Electi			

Course L0691: Integrated Circuit 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 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

Thesis

Module M-002: Master Thesis		
Courses		
Title	Typ Hrs/wk CP	
Module Responsible	Professoren der TUHH	
Admission Requirements	According to Congred Degulations \$21 /1);	
	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	The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized.	
	issues.	
	• The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject,	
	describing current developments and taking up a critical position on them.	
	The students can place a research task in their subject area in its context and describe and critically assess the state of	
	research.	
Skills	The students are able:	
	To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question. To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question.	
	 To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or incompletely defined problems in a solution-oriented way. 	
	 To develop new scientific findings in their subject area and subject them to a critical assessment. 	
Personal Competence		
Social Competence	Students can	
	Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured	
	way.	
	Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees	
	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 death into a largely unity and a which and to account to information required for them to do so.	
	 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. 	
	To apply the commission of solutions mark completions of the solution of the solutions of t	
	Independent Study Time 900, Study Time in Lecture 0	
Credit points		
Course achievement		
Examination		
Examination duration and scale	According to General Regulations	
	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	
1	Renewable Energies: Thesis: Compulsory	

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