

Module Manual

Master of Science (M.Sc.) Mechatronics

Cohort: Winter Term 2022 Updated: 24th April 2023

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Program description

Content

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

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

Career prospects

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

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

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

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

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

Learning target

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

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

System Design

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

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

Intelligent Systems and Robotics

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

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

Program structure

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

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

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

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

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

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

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

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

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

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

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

Core Qualification

Module M0523: Busine	ess & Management
Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	 Students are able to find their way around selected special areas of management within the scope of business management Students are able to explain basic theories, categories, and models in selected special areas of business management. Students are able to interrelate technical and management knowledge.
Skills	 Students are able to apply basic methods in selected areas of business management. Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.
Personal Competence	
Social Competence	• Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems
Autonomy	• Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.
Workload in Hours	Depends on choice of courses
Credit points	6

Courses

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

Module Responsible	Dagmar Richter
dmission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
rofessional Competence	
Knowledge	The Nontechnical Academic Programms (NTA)
	imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover Self-reliance, self-management, collaboration and professional and personnel management competences. The depart implements these training objectives in its teaching architecture , in its teaching and learning arrangements , in teac areas and by means of teaching offerings in which students can qualify by opting for specific competences and a compet level at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontecl complementary courses.
	The Learning Architecture
	consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontecl academic programms follow the specific profiling of TUHH degree courses.
	The learning architecture demands and trains independent educational planning as regards the individual developme competences. It also provides orientation knowledge in the form of "profiles".
	The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in o two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making transition from school to university and in order to encourage individually planned semesters abroad, there is no obligati study these subjects in one or two specific semesters during the course of studies.
	Teaching and Learning Arrangements
	provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of de with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliber encouraged in specific courses.
	Fields of Teaching
	are based on research findings from the academic disciplines cultural studies, social studies, arts, historical str communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the v semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and star in a goal-oriented way.
	The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.
	The Competence Level
	of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. I differences are reflected in the practical examples used, in content topics that refer to different professional application con and in the higher scientific and theoretical level of abstraction in the B.Sc.
	This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leade functions of Bachelor's and Master's graduates in their future working life.
	Specialized Competence (Knowledge)
	Students can
	 explain specialized areas in context of the relevant non-technical disciplines, outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented i learning area, different specialist disciplines relate to their own discipline and differentiate it as well as make connections, sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of represent in the specialized sciences are subject to individual and socio-cultural interpretation and historicity, Can communicate in a foreign language in a manner appropriate to the subject.
CL:II-	
SKIIIS	Professional Competence (Skills)
	 In selected sub-areas students can apply basic and specific methods of the said scientific disciplines, aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specific discipline, to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner, justify their decisions on forms of organization and application in practical questions in contexts that go beyond technical relationship to the subject.

Personal Competence

Social Competence Personal Competences (Social Skills)

	 Students will be able to learn to collaborate in different manner, to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees, to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen), to explain nontechnical items to auditorium with technical background knowledge.
Autonomy	Personal Competences (Self-reliance)
	Students are able in selected areas
	 to reflect on their own profession and professionalism in the context of real-life fields of application
	to organize themselves and their own learning processes
	 to reflect and decide questions in front of a broad education background to communicate a nontechnical item in a competent way in writen form or verbaly
	 to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)
Workload in Hours	Depends on choice of courses
Credit points	6

Courses

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

Module M0563: Robot	tics						
Courses							
					True	Line (usis	CP.
F itle Robotics: Modelling and Control (LC	168)				Typ Integrated Lecture	Hrs/wk 4	СР 4
Robotics: Modelling and Control (L1					Project-/problem-based Learning	2	2
Module Responsible							
Admission Requirements	None						
Recommended Previous	Fundamentals of el	ectrical engi	neering				
Knowledge							
	Broad knowledge o	f mechanics					
	Fundamentals of co	ontrol theory					
Educational Objectives	After taking part su	iccessfully, st	udents have r	eached the followin	ig learning results		
Professional Competence							
					nd solution approaches for mult	iple problems	in robotics.
Skills	Students are able t	o derive and	solve equation	is of motion for var	ious manipulators.		
	Students can gener	ate trajector	ies in various o	coordinate systems			
	Students can design linear and partially nonlinear controllers for robotic manipulators.						
	Students can desig	n linear and	partially nonlin	ear 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 assi	With instructor assistance, students are able to evaluate their own knowledge level and define a further course of study.					
	with instructor assi	stance, stud	ents are able t	o evaluate their ow	n knowledge level and deline a		e of study.
Workload in Hours	Independent Study	Time 96, Stu	idy Time in Leo	cture 84			
Credit points	6						
Course achievement	Compulsory Bonus	Form		Description			
	Yes None		theoretical		n PBL-Einheiten sowie Erreic	hen des Ge	samtziels und
		practical	work	jeweiligen Ses	ssion-Ziele		
Examination							
Examination duration and	120 min						
scale							
Assignment for the	Aircraft Systems Er						
Following Curricula		-			duct Development and Producti		ompulsory
	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory						
	Mechanical Engine	ering and Ma	nagement: Cor	re Qualification: Co	mpulsory		
	Mechatronics: Core	Qualification	n: Compulsory				
	Product Developme	ent, Materials	and Productio	n: Specialisation Pr	oduct Development: Elective C	ompulsory	
	Product Developme	ent, Materials	and Productio	n: Specialisation Pr	oduction: Elective Compulsory		
	Product Developme	ent, Materials	and Productio	n: Specialisation M	aterials: Elective Compulsory		
	Theoretical Mechar	nical Enginee	ring: Specialisa	ation Robotics and	Computer Science: Elective Con	npulsory	

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

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

Courses				
Title		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials	and Mechanics II (Hydrostatics, Kinematics, Dyn	amics)	
Knowledge	Mathematics I, II, III (in particular differentia	equations)		
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence	After taking part successivity, statemes nave			
	The students possess an in-depth knowled	ge regarding the derivation of the finite eleme	ant method and	are able to give
Knowledge	overview of the theoretical and methodical l			are able to give i
Skills	The students are capable to handle engine	ering problems by formulating suitable finite ele	ments, assemblir	ng the correspondi
	system matrices, and solving the resulting s	ystem of equations.		
Personal Competence				
Social Competence	Students can work in small groups on specif	c problems to arrive at joint solutions.		
Autonomy	The students are able to independently s	olve challenging computational problems and o	develop own fini	te element routine
	Problems can be identified and the results a			
	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6 Compulsory Bonus Form	Description		
Course achievement	No 20 % Midterm	Description		
Examination	Written exam			
Examination duration and				
scale				
Assignment for the	Civil Engineering: Core Qualification: Compu	lsorv		
	Energy Systems: Core Qualification: Elective			
	Aircraft Systems Engineering: Core Qualifica			
		Specialisation II. Mechatronics: Elective Compuls	ory	
		Specialisation II. Product Development and Produ		ompulsory
	Mechatronics: Core Qualification: Compulsor			. ,
	Biomedical Engineering: Specialisation Impl			
		gement and Business Administration: Elective Co	ompulsory	
		cal Technology and Control Theory: Elective Com		
		cial Organs and Regenerative Medicine: Elective		
	Product Development, Materials and Product			
	Technomathematics: Specialisation III. Engin			
	Theoretical Mechanical Engineering: Core Q			

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

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

Courses					
Title		Тур	Hrs/wk	СР	
Control Systems Theory and Design		Lecture	2	4	
Control Systems Theory and Design		Recitation Section (small)	2	2	
Module Responsible					
Admission Requirements					
	Introduction to Control Systems				
Knowledge	After taking part successfully, students have	reached the following learning results			
	After taking part successfully, students have i	eached the following learning results			
Professional Competence Knowledge					
Knowledge	 Students can explain how linear dyna 	mic systems are represented as state space m	odels; they can	interpret the syst	
	response to initial states or external ex	citation as trajectories in state space			
	 They can explain the system propertie 	s controllability and observability, and their rel	ationship to state	e feedback and st	
	estimation, respectively				
	They can explain the significance of a r				
		feedback and how it can be used to achieve tra	cking and disturb	ance rejection	
	 They can extend all of the above to mu They can explain the a transform and it 				
	 They can explain the z-transform and it They can explain state space models a 	nd transfer function models of discrete-time sys	ems		
		ntification of ARX models of dynamic systems, a		ification problem	
	be solved by solving a normal equation			incution problem	
		del can be constructed from a discrete-time imp	oulse response		
Skills	Students can transform transfer function	on models into state space models and vice vers	a		
	 They can assess controllability and obs 	ervability and construct minimal realisations			
	 They can design LQG controllers for mu 	Iltivariable plants			
	 They can carry out a controller design 	both in continuous-time and discrete-time dom	ain, and decide	which is appropr	
	for a given sampling rate				
		lels and state space models of dynamic systems			
		ing standard software tools (Matlab Control Too	olbox, System Id	entification Toolb	
	Simulink)				
Personal Competence					
Social Competence	Students can work in small groups on specific	problems to arrive at joint solutions.			
Autonomy	Students can obtain information from provid	ed sources (lecture notes, software document	ation, experimer	nt quides) and us	
	when solving given problems.				
	They can assess their knowledge in weekly or	n-line tests and thereby control their learning pro	ogress.		
Workload in Hours	Independent Study Time 124, Study Time in L	ecture 56			
Credit points	6				
Course achievement	None				
Examination					
Examination duration and					
scale	120 1111				
	Electrical Engineering: Core Qualification: Cor	npulsory			
5	Energy Systems: Core Qualification: Elective (
Ū.	Aircraft Systems Engineering: Core Qualificati				
	Computer Science in Engineering: Specialisati	on II. Engineering Science: Elective Compulsory			
	International Management and Engineering: S	pecialisation II. Electrical Engineering: Elective (Compulsory		
	International Management and Engineering: S	pecialisation II. Mechatronics: Elective Compuls	ory		
	Mechanical Engineering and Management: Sp	ecialisation Mechatronics: Elective Compulsory			
	Mechatronics: Core Qualification: Compulsory				
	· ·	al Organs and Regenerative Medicine: Elective (Compulsory		
	Biomedical Engineering: Specialisation Implar				
	· ·	al Technology and Control Theory: Compulsory	mulcori		
	Biomedical Engineering: Specialisation Manag Product Development, Materials and Production	ement and Business Administration: Elective Co	приізогу		
	risuace Development, materials and Froductio	shi core quanneation. Liective Compuisory			

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

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

Courses						
Title				Тур	Hrs/wk	СР
Design and Implementation of Soft	,			Lecture	2	3
Design and Implementation of Soft	,			Practical Course	2	3
Module Responsible	Prof. Bernd-Christian	Renner				
Admission Requirements	None					
Recommended Previous	- Imperativ program	ming languages (C	, Pascal, Fortran or sim	ilar)		
Knowledge	- Simple data types	(integer, double, ch	nar, boolean), arrays, if	-then-else, for, while, proc	edure and function ca	lls
Educational Objectives	After taking part suc	cessfully, students	have reached the follo	wing learning results		
Professional Competence						
Knowledge	Students are able to	describe mechatro	onic systems and define	e requirements.		
Skills	kills Students are able to design and implement mechatronic systems. They are able to argue the combination of Hard- a				of Hard- and Softwa	
	and the interfaces.					
Personal Competence						
Social Competence	Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities and define task with					
	the team.					
Autonomy	Students are able to solve individually exercises related to this lecture with instructional direction. Students are able to pla					
hatohomy	execute and summa		•			ne and able to ple
Workload in Hours	Independent Study 1	Time 124, Study Tir	me in Lecture 56			
Credit points	6					
Course achievement		Form	Description			
	No 10 %	Attestation				
	Written exam					
Examination duration and	90 min					
scale						
Assignment for the	Mechatronics: Core (Qualification: Comp	oulsory			
Following Curricula						

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	
CP	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				
Knowledge	Calculus			
	Linear Algebra Engineering Mechanics			
	Engineering Mechanics			
Educational Objectives	After taking part successfully, students have	ve reached the following learning results		
Professional Competence				
Knowledge			6 H	
		and concepts of Vibration Theory and develop the		dia mandri a su a
		g and simulation for free, driven, self-excited and	a parameter driven	vibrations.
	 Students know about concepts of lin Students know basis tasks of vibrati 			
	 Students know basic tasks of vibrati 	on problems of discrete and continuous systems		
Skills				
		Is of Vibration Theory and develop them further.	free ferred celf ov	sited and nevera
	 Students are able to apply and explored active vibrations. 	pand methods of modeling and simulation for 1	rree, torced, selt-ex	cited and parame
		d poplinger vibration problems		
	 Students are able to solve linear and 	a nonimear vibration problems.		
Personal Competence				
Social Competence		lana wala a than a ta sa haraka wala ina aka wala		
		elems, work on them, and reach working results a	also in teams or gro	ups.
	 Students are able to document the l 	results of vibration studies also in groups.		
Autonomy				
	Students are able to individually and Students are able to approach indivi-			
	 Students are able to approach indiv 	idually 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	ve Compulsory		
Following Curricula	International Management and Engineering	g: Specialisation II. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management:	Specialisation Mechatronics: Elective Compulso	ry	
	Mechatronics: Core Qualification: Compuls	ory		
	Biomedical Engineering: Specialisation Art	ificial Organs and Regenerative Medicine: Electiv	e Compulsory	
		plants and Endoprostheses: Elective Compulsory		
	5 5 1	dical Technology and Control Theory: Elective Co	1	
		nagement and Business Administration: Elective	Compulsory	
	Product Development, Materials and Produ			
	Naval Architecture and Ocean Engineering			
	Theoretical Mechanical Engineering: Core	Qualification: Elective Compulsory		
Course L0701: Vibration The	eory			
Тур	Integrated Lecture			

Course L0701: Vibration The	
Тур	Integrated Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	WiSe
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Vibrations Free vibration Self-excited vibration Forced vibration Multi degree of freedom vibration Continuum vibration Irregular vibration
Literature	German - K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. English - K. Magnus: Vibrations.

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

Module M0836: Comr	nunication Networks			
Courses				
Title		Тур	Hrs/wk	СР
Selected Topics of Communication	Networks (L0899)	Project-/problem-based Learning	2	2
Communication Networks (L0897)		Lecture	2	2
Communication Networks Excercise (L0898) Project-/problem-based Learning 1				2
Module Responsible	Prof. Andreas Timm-Giel			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamental stochastics			
Educational Objectives	After taking part successfully, students have reache	ed the following learning results		
Professional Competence				
Knowledge	Students are able to describe the principles and structures of communication networks in detail. They can explain the form description methods of communication networks and their protocols. They are able to explain how current and comple communication networks work and describe the current research in these examples.			
Skills	s Students are able to evaluate the performance of communication networks using the learned methods. They are able to work o problems themselves and apply the learned methods. They can apply what they have learned autonomously on further and ne communication networks.			
Personal Competence				
Social Competence	Students are able to define tasks themselves in small teams and solve these problems together using the learned methods. The can present the obtained results. They are able to discuss and critically analyse the solutions.			
Autonomy	Students are able to obtain the necessary expert knowledge for understanding the functionality and performance capabilities new communication networks independently.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture	e 70		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	1.5 hours colloquium with three students, therefore	e about 30 min per student. Topics of the col	loquium are t	he posters from t
scale	previous poster session and the topics of the modul	e.		
Assignment for the	Electrical Engineering: Specialisation Information ar	nd Communication Systems: Elective Compuls	ory	
Following Curricula	Electrical Engineering: Specialisation Control and Po	ower Systems Engineering: Elective Compulso	ry	
	Aircraft Systems Engineering: Core Qualification: El	ective Compulsory		
	Computer Science in Engineering: Specialisation I. C	Computer Science: Elective Compulsory		
	Information and Communication Systems: Specialis	ation Communication Systems: Elective Comp	oulsory	
	Information and Communication Systems: Specialis		-	Elective Compulso
	International Management and Engineering: Special			
	Aeronautics: Core Qualification: Elective Compulsor			
	Mechatronics: Core Qualification: Elective Compulso			
	Microelectronics and Microsystems: Specialisation C	•	e Compulsorv	

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

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

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

Courses				
Fitle Energy Efficiency in Embedded Sys Energy Efficiency in Embedded Sys	tems (L2872)	Typ Lecture Project-/problem-based Lea		CP 3 2
nergy Efficiency in Embedded Sys		Recitation Section (large)	1	1
Module Responsible				
•	None			
Recommended Previous Knowledge	 Computer Engineering (mandatory) Programming Skills in C (mandatory) Computer Architecture (recommendation) 	/)		
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence				
Knowledge	we are dependent on the manufacturers we are given at the system level, we no dissipation in embedded systems. When	only limited possibilities to influence the efficien (e.g. of microcontrollers). However, in order to e eed a deeper understanding of the backgroun e does the power dissipation come from, wha what is the tradeoff between flexibility and effici rent.	exploit the full pote d, processes and n t happens at the l	ntial of the hardw nechanisms of po nardware level, w
	Contents of teaching:			
	 Motivation and power dissipation or Power dissipation of digital circuits, Power Management in Hard- and So Energy efficient system design (app Energy Harvesting and Transiently 	inparticular CMOS oftware (Sleep Modes, DVS, FS, Undervolting) plications)		
Skills	s Upon completion of this module, students will have a deeper understanding of hardware and software mechanisms for evaluatin and developing energy-efficient embedded systems			
	They can analyze the power dissipaThey can use a variety of standard	of the electrotechnical basics of power dissipatic ation of systems at any level and apply appropria techniques to achieve "Energy Efficiency by Des s implement energy-autonomous systems	te methods to incre	
Personal Competence				
-	As part of the module, concepts learned in the lecture will be implemented on a hardware platform within small groups. Stu learn to work in a team and to develop solutions together. Specific tasks are worked on within the group, whereby cross- collaboration (exchange) also takes place. The second part is a challenge-based project in which the groups find the most er efficient solutions possible in healthy competition with each other. This strengthens the cohesion in the groups and reinf mutual motivation, support and creativity.		whereby cross-gro find the most ener	
Autonomy		will be able to independently develop, optimize ve acquired and further technical literature.	e and evaluate sol	utions for embed
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				
-	Electrical Engineering: Specialisation Nano		ive Compulsory	

Course L2870: Energy Efficie	
<i>,</i> ,	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ulf Kulau
Language	DE/EN
Cycle	WiSe
	Motivation: In the field of computer science we have only limited possibilities to influence the efficiency of the hardware directly, respectively we are dependent on the manufacturers (e.g. of microcontrollers). However, in order to exploit the full potential of the hardware we are given at the system level, we need a deeper understanding of the background, processes and mechanisms of power dissipation in embedded systems. Where does the power dissipation come from, what happens at the hardware level, what mechanisms can I use directly/indirectly, what is the tradeoff between flexibility and efficiency, are only a few questions, which will be elaborated and discussed in this event. Contents of teaching: • Motivation and power dissipation on semiconductor level • Power dissipation of digital circuits, inparticular CMOS • Power Management in Hard- and Software (Sleep Modes, DVS, FS, Undervolting) • Energy efficient system design (applications) • Energy Harvesting and Transiently Powered Computing (TPC)
Literature	 DE: Die Vorlesung basiert af einer Vielzahl von Quellen, welche in [1.] angegeben sind. ENG: The lecture is based on multiple sources which are listed in [1.]. 1. Kulau, Ulf: Course: Energy Efficiency in Embedded Systems-A System-Level Perspective for Computer Scientists, EWME, 2018. 2. Harris, David, and N. Weste: CMOS VLSI Design ed., Pearson Education, 2010 3. Rabaey, Jan: Low Power Design Essentials (Integrated Circuits and Systems), Springer, 2009

Course L2872: Energy Efficie	ncy in Embedded Systems
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ulf Kulau
Language	DE/EN
Cycle	WiSe
Content	 In this project-based exercise, the learned aspects for achieving energy-efficient embedded systems are implemented and consolidated in practical environments in a small project. First, a tool set for the implementation of energy efficiency mechanisms is implemented in common exercises by means of defined tasks. In the second part, a challenge-based exercise is carried out in which a system that is as efficient as possible is to be implemented independently. A system based on an AVR micro-controller is used, which can be operated autonomously by a Solar-Energy Harvester. 1. Task phase: 6 "hands-on" tasks to gain experience and to create a SW library. 2. Project phase: Implementation of an energy autonomous system with the goal of highest possible energy efficiency (Challenge)
Literature	

Course L2871: Energy Efficie	ency in Embedded Systems
Тур	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Ulf Kulau
Language	DE/EN
Cycle	WiSe
Content	In the lecture hall exercise, the theoertical basics taught in the lecture are deepened. This is done through in-depth discussion of relevant aspects, but also through calculation examples, in which a deeper understanding of the topic of energy efficiency in embedded systems is gained. Exercises will be distributed in advance and solutions will be presented in the lecture hall exercise. Contents of the exercise are as follows: Basics and calculation of power dissipation on semiconductor Power dissipation of CMOS using the example of an inverter Influence of the activity factor and external components DVS and scheduling Evaluation to show the benefit of undervolting Aspects of energy harvesting (MPPT)
Literature	

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				
Courses				
Title		Тур	Hrs/wk	СР
Approximation and Stability (L0487	7)	Lecture	3	4
Approximation and Stability (L0488	3)	Recitation Section (small)	1	2
Module Responsible	Prof. Marko Lindner			
Admission Requirements	None			
Recommended Previous	 Linear Algebra: systems of linear og 	quations, least squares problems, eigenvalues, sin	gular valuos	
Knowledge	 Analysis: sequences, series, differer 		guiai values	
	• Analysis. sequences, series, unreren			
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	 skotch and interrolate basic concern 	ts of functional analysis (Hilbert space, operators)		
	 name and understand concrete app 		,	
	 name and explain basic stability the 			
		ons numbers and methods of regularisation		
	- discuss spectral quantities, contacto			
Skills	Students are able to			
	 apply basic results from functional a 	analvsis.		
	 apply approximation methods, 			
	 apply stability theorems, 			
	 compute spectral quantities, 			
	 apply regularisation methods. 			
Personal Competence				
Social Competence	Students are able to solve specific problem	ns in groups and to present their results appropria	tely (e.g. as a sen	ninar presentation).
Autonomy				
Autonomy	 Students are capable of checking t 	heir understanding of complex concepts on their	own. They can sp	ecify open question
	precisely and know where to get he	lp in solving them.		
	Students have developed sufficient	t persistence to be able to work for longer perio	ds in a goal-orier	ited manner on ha
	problems.			
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points				
Course achievement	Compulsory Bonus Form	Description		
	Yes None Presentation			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Cont	rol and Power Systems Engineering: Elective Com	pulsory	
Following Curricula	Mechatronics: Specialisation Intelligent Sys	stems and Robotics: Elective Compulsory		
	Technomathematics: Specialisation I. Math	hematics: Elective Compulsory		
	Theoretical Mechanical Engineering: Speci	alisation Robotics and Computer Science: Elective	Compulsory	

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

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

Module M0752: Nonli	near Dynamics				
Courses					
Title			Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)			Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous	Calculus				
Knowledge	 Linear Algebra 				
	Engineering Mechanics				
Educational Objectives	After taking part successfully, stu	dents have reached the follo	wing learning results		
Professional Competence					
Knowledge	 Students are able to reflect 	t oxisting torms and concont	s in Nonlinger Dynamics an	d to dovelop and res	oarch now torms
	concepts.	c existing terms and concept	s in Nonlinear Dynamics an		earch new terms
	 Students are able to denot 	e and expand methods of mo	odeling and analysis for non	linear dynamical sys	tems
			and analysis for non		
Skills	 Students are able to apply 	existing methods and proces	sures of Nonlinear Dynamics	-	
	 Students are able to doppy Students are able to devel 				
Personal Competence					
Social Competence	 Students can analyze prob 	lems of nonlinear dynamics a	also in groups		
	 Students can achieve solution 			tems also in groups.	
Autonomy	 Students are able to approx 	ach given research tasks on	the basis of given methods	individually.	
	 Students are able to identi 	fy and follow up novel resear	ch tasks by themselves.	-	
Workload in Hours		idy Time in Lecture 56			
Credit points	6				
Course achievement Examination					
Examination Examination duration and	2 Hours				
scale	2 Hours				
	Aircraft Systems Engineering: Co	re Qualification: Elective Com	pulsory		
Following Curricula	International Management and E			pulsory	
	Mechanical Engineering and Man				
	Mechatronics: Specialisation Syst	- ,			
	Mechatronics: Specialisation Inte	ligent Systems and Robotics:	Elective Compulsory		
	Biomedical Engineering: Specialis	ation Artificial Organs and Re	egenerative Medicine: Elect	ive Compulsory	
	Biomedical Engineering: Specialis	ation Implants and Endopros	theses: Elective Compulsor	у	
	Biomedical Engineering: Specialis	ation Medical Technology an	d Control Theory: Elective C	Compulsory	
	Biomedical Engineering: Specialis	ation Management and Busin	ness Administration: Electiv	e Compulsory	
	Product Development, Materials	and Production: Core Qualification	ation: Elective Compulsory		
	Theoretical Mechanical Engineeri	ng: Core Qualification: Electiv	o Compulsory		

Course L0702: Nonlinear Dyr	namics	
Тур	Integrated Lecture	
Hrs/wk		
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	
	 One dimensional problems Linear Stability Local Bifurcations Synchronisation Two dimensional problems Limit Cycles Global Bifurcations Chaos Lorenz Equations Fractals and Strange Attractors Predictability and Horizons 	
Literature	Steven Strogatz: Nonlinear Dynamics and Chaos.	

Courses				
Title		Тур	Hrs/wk	СР
Numerical Treatment of Ordinary D	ifferential Equations (L0576)	Lecture	2	3
Numerical Treatment of Ordinary D	ifferential Equations (L0582)	Recitation Section (small)	2	3
Module Responsible	Prof. Daniel Ruprecht			
Admission Requirements	None			
Recommended Previous	Mathematik für Ingenieurstu	dierende (deutsch oder englisch) oder Analysis &	Lineare Algebra I	+ Il sowie Analysi
Knowledge	für Technomathematiker	derende (deutsch oder englisch) oder Analysis a	Lineare Aigebra i	T II SOWIE Analysi
	Basic knowledge of MATLAB, Pythor	n or a similar programming language		
	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	 list numerical methods for the solut 	ion of ordinary differential equations and explain t	heir core ideas,	
	formulate convergence statements	for the treated numerical methods (including t	the assumptions	about the underly
	problem),			
	 explain aspects regarding the pract 	ical realisation of a method.		
	 select the appropriate numerical 	method for concrete problems, implement the	numerical algor	rithms efficiently
	interpret the numerical results			
Skills	Students are able to			
	 implement, apply and compare numerical methods for the solution of ordinary differential equations, institute convergence behaviour of numerical methods with respect to the posed problem and colocted algorithm 			
	 justify the convergence behaviour of numerical methods with respect to the posed problem and selected algorithm, develop a suitable solution approach for a given problem, if processary by combining of coveral algorithms, and to realise 			
	 develop a suitable solution approach for a given problem, if necessary by combining of several algorithms, and to realis this approach and critically evaluate the results. 			
Personal Competence				
Social Competence	Students are able to			
	 work together in beterogeneously of 	composed teams (i.e., teams from different study	programs and ba	ckaround knowled
		support each other with practical aspects regarding		
			5	5
Autonomy	Students are capable			
	 to assess whether the supporting the 	neoretical and practical excercises are better solve	ed individually or	in a team,
	• to assess their individual progress a	and, if necessary, to ask questions and seek help.		
Weyldood in House	Independent Study Time 124, Study Time	in Lookura EC		
Credit points	Independent Study Time 124, Study Time			
Course achievement				
Examination	Written exam			
Examination duration and				
scale				
Assignment for the	Bioprocess Engineering: Specialisation A -	General Bioprocess Engineering: Elective Compute	sory	
Following Curricula	Chemical and Bioprocess Engineering: Spe	ecialisation Chemical Process Engineering: Elective	e Compulsory	
	Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory			
	Computer Science: Specialisation III. Math	ematics: Elective Compulsory		
	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory			
	Energy Systems: Core Qualification: Electi			
	Aircraft Systems Engineering: Core Qualifi			
		on II. Numerical - Modelling Training: Compulsory		
	Mechatronics: Specialisation Intelligent Sy	stems and Robotics: Elective Compulsory		
	- I II I			
	Technomathematics: Specialisation I. Math			
	Theoretical Mechanical Engineering: Core			

Course L0576: Numerical Tre	atment of Ordinary Differential Equations
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Daniel Ruprecht
Language	DE/EN
Cycle	SoSe
	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
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. D. Griffiths, D. Higham: Numerical Methods for Ordinary Differential Equations.

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

Courses				
Title		Тур	Hrs/wk	СР
Optimal and Robust Control (L0658)	Lecture	2	3
Optimal and Robust Control (L0659		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements				
Recommended Previous				
Knowledge	 Classical control (frequency response, root locus) 			
	State space methods			
	 Linear algebra, singular value decomposition 			
Educational Objectives	After taking part successfully, students have reached the fo	ollowing learning results		
Professional Competence				
Knowledge				
	Students can explain the significance of the matrix F		-	
	They can explain the duality between optimal state to the state of the state o			
	They can explain how the H2 and H-infinity norms and They can explain how on LOC design problem can be			
	They can explain how an LQG design problem can be They can explain how model uncertainty can be con		÷ ,	
	 They can explain how model uncertainty can be rep They can explain how - based on the small gain the 			
	an uncertain plant.		arantee stability	
	 They understand how analysis and synthesis condition 	ons on feedback loops can be repre	esented as linear	matrix inequalitie
Skills	 Students are capable of designing and tuning LQG or 	ontrollers for multivariable plant m	odels	
	 They are capable of representing a H2 or H-infinity of 			nd of using stand
	software tools for solving it.	g. p		··- ·· ··· · · · · · · · · · · · · · ·
	 They are capable of translating time and frequency 	domain specifications for control	loops into constr	aints on closed-l
	sensitivity functions, and of carrying out a mixed-ser			
	• They are capable of constructing an LFT uncertain	ty model for an uncertain system	, and of designin	ig a mixed-object
	robust controller.			
	They are capable of formulating analysis and synthe	esis conditions as linear matrix ine	qualities (LMI), a	nd of using stand
	LMI-solvers for solving them.			
	They can carry out all of the above using standard set	oftware tools (Matlab robust contro	l toolbox).	
Personal Competence				
	Students can work in small groups on specific problems to	arrive at joint solutions		
	Students are able to find required information in sources p		oftware documer	ntation) and use i
Autonomy	solve given problems.	iovided (lecture notes, interature, s	ortware document	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
Examination				
Examination duration and				
scale	50 mm			
Start				
-	Electrical Engineering: Specialisation Control and Power Sy	stems Engineering: Elective Compu	ulsory	
Following Curricula	Energy Systems: Core Qualification: Elective Compulsory			
	Aircraft Systems Engineering: Core Qualification: Elective C			
	Mechatronics: Specialisation Intelligent Systems and Robot	1 2		
	Mechatronics: Specialisation System Design: Elective Comp		Compulson	
	Biomedical Engineering: Specialisation Artificial Organs and	-	Lornpuisory	
	Biomedical Engineering: Specialisation Implants and Endop		aulcon:	
	Biomedical Engineering: Specialisation Medical Technology Biomedical Engineering: Specialisation Management and B		-	
	Product Development, Materials and Production: Specialisa			
	Product Development, Materials and Production: Specialisa Product Development, Materials and Production: Specialisa			
	Product Development, Materials and Production: Specialisa Product Development, Materials and Production: Specialisa		-	

	Les Nord	
	Typ Lecture	
	Hrs/wk 2	
CP		
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 	

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

Hrs 3 on (large) 1	s/wk	
3		CP
on (large) 1		4
		2
ilts		
avalanment of complex	av Evetome	c
evelopment of comple	x systems	د
for aircraft		
reliability		
,		
ased requirements en	ngineering	(MBRE)
critical systems		
Elective Compulsory	lective Cor	mpulsory
ent and Production: El		
ent and Production: Ele ory ment: Compulsory		
ent and Production: El- ory ment: Compulsory ive Compulsory		
	Elective Compulsory eent and Production: El sory ment: Compulsory	ent and Production: Elective Cor

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

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

Courses			
itle	Тур	Hrs/wk	СР
Module Responsible	NN		
Admission Requirements	None		
Recommended Previous	See selected module according to FSPO		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	see selected module according to FSPO		
Skills	see selected module according to FSPO		
Personal Competence			
•	see selected module according to FSPO		
Social Competence	see selected module according to 150		
Autonomy	see selected module according to FSPO		
Workload in Hours	Depends on choice of courses		
Credit points	6		
Assignment for the	Mechatronics: Specialisation System Design: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory		

Module M1223: Select	ed Topics of Mechatronics (Alternative A: 1	L2 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Applied Automation (L1592)		Project-/problem-based Learning	3	3
Advanced Training Course SE-ZERT	(L2739)	Project-/problem-based Learning	2	3
Development Management for Mech	atronics (L1512)	Lecture	2	3
Fatigue & Damage Tolerance (L031)))	Lecture	2	3
ndustry 4.0 for engineers (L2012)		Lecture	2	3
Microcontroller Circuits: Implementa	tion in Hardware and Software (L0087)	Seminar	2	2
Microsystems Technology (L0724)		Lecture	2	4
Model-Based Systems Engineering (MBSE) with SysML/UML (L1551)	Project-/problem-based Learning	3	3
Sustainable Industrial Production (L	2863)	Lecture	2	4
Process Measurement Engineering (L1077)	Lecture	2	3
Process Measurement Engineering (L1083)	Recitation Section (large)	1	1
Feedback Control in Medical Techno	logy (L0664)	Lecture	2	3
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the followi	ing learning results		
Professional Competence				
Knowledge				
	 Students are able to express their extended knowledge a 	and discuss the connection of di	fferent specia	l fields or applicat
	areas of mechatronics			
	 Students are qualified to connect different special fields w 	vith each other		
Skills				
SKIIIS	 Students can apply specialized solution strategies and ne 	w scientific methods in selected	areas	
	• Students are able to transfer learned skills to new and un	known problems and can develo	p own solutior	approaches
Personal Competence				
-	Nono			
Social Competence	NUIE			
Autonomy	 Students are able to develop their knowledge and skills b 	y autonomous election of course	s.	
Workload in Hours	Depends on choice of courses			
Credit points				
Credit points Assignment for the	¹² Mechatronics: Specialisation System Design: Elective Compulsor	rv		

Course L1592	2: Applied Automation
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in	Independent Study Time 48, Study Time in Lecture 42
Hours	
Examination	Mündliche Prüfung
Form	
Examination	30 Minuten
duration	
and scale	
	Prof. Thorsten Schüppstuhl
Language	
Cycle Content	
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 L2739: Advanced Training Course SE-ZERT		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	120 min	
scale		
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content		
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der deutschen Übersetzung), ISBN 978-3-9818805-0-2. ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System Life Cycle Processes).	

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

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

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

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

Course L0724: Microsystems	Technology
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	
scale	
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	
Content	
	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, roy 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 (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive esensor: segnetic estance, AMR and GMR, fluxquate magnetometer) Chemical and Blo Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, clambda probe, MOSFET gas sensor, pri-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 a
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009 T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

Тур	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung
Examination duration and	ca. 10 Seiten
scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal language
	SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Base
	Systems Engineering (MBSE) on a realistic hardware platform (e.g. Arduino®, Raspberry Pi®):
	What is a model?
	What is Systems Engineering?
	Survey of MBSE methodologies
	The modelling languages SysML /UML
	Tools for MBSE
	Best practices for MBSE
	Requirements specification, functional architecture, specification of a solution
	From model to software code
	Validation and verification: XiL methods
	Accompanying MBSE project
Literature	- Skript zur Vorlesung
Literature	- Skipt zur Vollesung - Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008
	- Weintens, T.: Systems Engineering mit Sysmi, one. Modellering, Analyse, Design. 2. Aurage, dpunkt. verag, 2008 - Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011
	- noit, J., reny, S.A., brownsword, M.: Model-based Requirements Engineering. Institution Engineering & Tech, 2011

Тур	Lecture
Hrs/wk	
CP	4
-	4 Independent Study Time 92, Study Time in Lecture 28
ixamination duration and	
scale	
	Dr. Simon Markus Kothe
Language	
Cycle	
Content	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufactur processes that change the form and physical properties of raw materials. Manufacturing is a central driver of econo development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities resi in enormous global energy and material demands that are harmful to both the environment and people. Historically, indust activities were mostly oriented towards economic constraints, while social and environmental consequences were only ha considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the nat regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. Thi emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Ear annual regenerative capacity. This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cycle products. For this, the following topics will be highlighted: - Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance tomorrow's manufacturing; - raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for environmental impact of manufactured products; - Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy a resource efficiency;
	 Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps modeling (1), evaluating (2) and improving (3); Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA); Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product cycle assessment.
Literature	Literatur:
	- Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing.
	 Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Ch Springer International Publishing. Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapo Springer.
	 Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer Internatio Publishing. Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG.

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

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

Course L0664: Feedback Con	strol in Medical Technology	
	Lecture	
Hrs/wk		
CP		
	J Independent Study Time 62, Study Time in Lecture 28	
Examination Form		
Examination duration and	5	
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. 	

Courses				
Title		Тур	Hrs/wk	СР
Applied Automation (L1592)		Project-/problem-based Learning	3	3
Advanced Training Course SE-ZER	(L2739)	Project-/problem-based Learning	2	3
Development Management for Med	natronics (L1512)	Lecture	2	3
atigue & Damage Tolerance (L03	0)	Lecture	2	3
ndustry 4.0 for engineers (L2012)		Lecture	2	3
Aicrocontroller Circuits: Implement	ation in Hardware and Software (L0087)	Seminar	2	2
Microsystems Technology (L0724)		Lecture	2	4
Model-Based Systems Engineering	MBSE) with SysML/UML (L1551)	Project-/problem-based Learning	3	3
Sustainable Industrial Production (I	2863)	Lecture	2	4
Process Measurement Engineering	L1077)	Lecture	2	3
Process Measurement Engineering	L1083)	Recitation Section (large)	1	1
eedback Control in Medical Techn	logy (L0664)	Lecture	2	3
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
5	After taking part successfully, students have reached the fol	llowing learning results		
5	After taking part successfully, students have reached the fol	llowing learning results		
Educational Objectives	·			
Educational Objectives Professional Competence	Students are able to express their extended knowled		fferent special	l fields or applicat
Educational Objectives Professional Competence	·		fferent special	fields or applicat
Educational Objectives Professional Competence	Students are able to express their extended knowled	ge and discuss the connection of di	fferent special	fields or applicat
Educational Objectives Professional Competence Knowledge	 Students are able to express their extended knowled areas of mechatronics 	ge and discuss the connection of di	fferent special	fields or applicat
Educational Objectives Professional Competence	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special field 	dge and discuss the connection of di	·	fields or applicat
Educational Objectives Professional Competence Knowledge	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special fiel Students can apply specialized solution strategies and 	ge and discuss the connection of di lds with each other d new scientific methods in selected	areas	
Educational Objectives Professional Competence Knowledge	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special field 	ge and discuss the connection of di lds with each other d new scientific methods in selected	areas	
Educational Objectives Professional Competence Knowledge	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special fiel Students can apply specialized solution strategies and 	ge and discuss the connection of di lds with each other d new scientific methods in selected	areas	
Educational Objectives Professional Competence Knowledge Skills	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special fiel Students can apply specialized solution strategies and Students are able to transfer learned skills to new and 	ge and discuss the connection of di lds with each other d new scientific methods in selected	areas	
Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special fiel Students can apply specialized solution strategies and Students are able to transfer learned skills to new and 	ge and discuss the connection of di lds with each other d new scientific methods in selected	areas	
Educational Objectives Professional Competence Knowledge Skills Personal Competence	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special fiel Students can apply specialized solution strategies and Students are able to transfer learned skills to new and 	lge and discuss the connection of di lds with each other d new scientific methods in selected d unknown problems and can develop	areas p own solutior	
Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special fiel Students can apply specialized solution strategies and Students are able to transfer learned skills to new and 	lge and discuss the connection of di lds with each other d new scientific methods in selected d unknown problems and can develop	areas p own solutior	
Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special fiel Students can apply specialized solution strategies and Students are able to transfer learned skills to new and None Students are able to develop their knowledge and ski 	lge and discuss the connection of di lds with each other d new scientific methods in selected d unknown problems and can develop	areas p own solutior	
Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Credit points	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special fiel Students can apply specialized solution strategies and Students are able to transfer learned skills to new and None Students are able to develop their knowledge and ski 	ge and discuss the connection of di lds with each other d new scientific methods in selected d unknown problems and can develop lls by autonomous election of course	areas p own solutior	
Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Credit points Assignment for the	 Students are able to express their extended knowled areas of mechatronics Students are qualified to connect different special fiel Students can apply specialized solution strategies and Students are able to transfer learned skills to new and None Students are able to develop their knowledge and ski Depends on choice of courses 6	lge and discuss the connection of di lds with each other d new scientific methods in selected d unknown problems and can develop lls by autonomous election of course	areas p own solutior	

Course L1592	2: Applied Automation
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in	Independent Study Time 48, Study Time in Lecture 42
Hours	
Examination	Mündliche Prüfung
Form	
Examination	30 Minuten
duration	
and scale	
	Prof. Thorsten Schüppstuhl
Language	
Cycle	
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 L2739: Advanced Training Course SE-ZERT		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	120 min	
scale		
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content		
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der deutschen Übersetzung), ISBN 978-3-9818805-0-2. ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System Life Cycle Processes).	

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

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

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

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

Course L0724: Microsystems	Technology
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, LPCVD 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, pi 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, piezoresistivy, pressure sensor: piezoresistive, capacitive and fabrication process) Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensor: pellistor and thermal conductivity sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) Micro Actuators, Microfludics and TAS (drives: thermal, electrostatic, piezo electric and electromagnet
	TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

Тур	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung
Examination duration and	ca. 10 Seiten
scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal language
	SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Base
	Systems Engineering (MBSE) on a realistic hardware platform (e.g. Arduino®, Raspberry Pi®):
	What is a model?
	What is Systems Engineering?
	Survey of MBSE methodologies
	The modelling languages SysML /UML
	Tools for MBSE
	Best practices for MBSE
	Requirements specification, functional architecture, specification of a solution
	From model to software code
	Validation and verification: XiL methods
	Accompanying MBSE project
Literature	- Skript zur Vorlesung
Literature	- Skipt zur Vollesung - Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008
	- Weintens, T.: Systems Engineering mit Sysmi, one. Modellering, Analyse, Design. 2. Aurage, dpunkt. verag, 2008 - Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011
	- noit, J., reny, S.A., brownsword, M.: Model-based Requirements Engineering. Institution Engineering & Tech, 2011

Тур	Lecture		
Hrs/wk			
CP	4		
-	4 Independent Study Time 92, Study Time in Lecture 28		
ixamination duration and	Klausur 60 min		
scale			
	Dr. Simon Markus Kothe		
Language			
Cycle			
Content	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufactur processes that change the form and physical properties of raw materials. Manufacturing is a central driver of econo development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities resi in enormous global energy and material demands that are harmful to both the environment and people. Historically, indust activities were mostly oriented towards economic constraints, while social and environmental consequences were only ha considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the nat regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. Thi emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Ear annual regenerative capacity. This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cycle products. For this, the following topics will be highlighted: - Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance tomorrow's manufacturing; - raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for environmental impact of manufactured products; - Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy a resource efficiency;		
	 Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps modeling (1), evaluating (2) and improving (3); Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA); Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product cycle assessment. 		
Literature	Literatur:		
	- Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing.		
	 Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Ch Springer International Publishing. Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapo Springer. 		
	 Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer Internatio Publishing. Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG. 		

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

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

Course L0664: Feedback Con	ntrol in Medical Technology		
	Lecture		
Hrs/wk			
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form			
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. 		

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

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

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Courses			
Fitle _ab Cyber-Physical Systems (L1740)) Project-/problem-based Learning	Hrs/wk 4	СР 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 environm actors. Due to their particular application areas, highly specialized sensors, processor is a large variety of different specification approaches for CPS - in contrast to classical Based on practical experiments using robot kits and computers, the basics of speci		s are commor ngineering ap modelling of	n. Accordingly, th proaches. CPS are taught. ⁻
	lab introduces into the area (basic notions, characteristical properties) and their specification tech hierarchical automata, data flow models, petri nets, imperative approaches). Since CPS frequentl experiments will base on simple control applications. The experiments will use state-of-the- (MATLAB/Simulink, LabVIEW, NXC) in order to model cyber-physical models that interact with t actors.	ly perform co -art industrial	ntrol tasks, the la
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 converted 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 specificat		
Personal Competence	tools and in the area of simple control applications.		
	Students are able to solve similar problems alone or in a group and to present the results accordin	ngly.	
Autonomy	Students are able to acquire new knowledge from specific literature and to associate this knowled	ge with other	classes.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Written elaboration		
Examination duration and	Execution and documentation of all lab experiments		
scale			
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Computer Science: El	ective Compu	llsory
Following Curricula	Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory		
	Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective (Compulsory	
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective Compulsory		

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

Module M1306: Contr	ol Lab C			
Courses				
Fitle		Тур	Hrs/wk	СР
Control Lab IX (L1836)		Practical Course	1	1
Control Lab VII (L1834)		Practical Course	1	1
Control Lab VIII (L1835)		Practical Course	1	1
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	State space methods			
	LQG control			
	 H2 and H-infinity optimal control 	1		
	 uncertain plant models and robu 	ust control		
	LPV control			
Educational Objectives	After taking part successfully students	have reached the following learning results		
Professional Competence	After taking part successfully, statents	nave reached the following learning results		
-				
Knowledge	Students can explain the differe	nce between validation of a control lop in simulation	on and experimental v	validation
Skills	Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify			
			stem identification id	londox) to identii
	dynamic model that can be used	•		
		ndard software tools (Matlab Control Toolbox) for	the design and imp	lementation of l
	controllers			
	 They are capable of using stand 	lard software tools (Matlab Robust Control Toolbox) for the mixed-sensit	ivity design and
	implementation of H-infinity opt	imal controllers		
	They are capable of representing	g model uncertainty, and of designing and implem	enting a robust contro	oller
	 They are capable of using stand 	ard software tools (Matlab Robust Control Toolbox)	for the design and th	e implementatio
	LPV gain-scheduled controllers			
Personal Competence				
Social Competence	 Students can work in teams to c 	conduct experiments and document the results		
Autonomy	- Chudente con independently con	n out circulation studios to design and validate of	ntral la ana	
	 Students can independently can 	ry out simulation studies to design and validate co	ntrol loops	
Workload in Hours	Independent Study Time 48, Study Tim	ne in Lecture 42		
Credit points	3			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	1			
scale				
Assignment for the	Electrical Engineering: Specialisation C	control and Power Systems Engineering: Elective Co	ompulsory	
Following Curricula	Mechatronics: Specialisation Intelligent	Systems and Robotics: Elective Compulsory		
-	Mechatronics: Specialisation System D			
		pre Qualification: Elective Compulsory		

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

Course L1834: Control Lab V	11
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Herbert Werner, Patrick Göttsch
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

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

Module M1281: Adva	nced Topics in Vibration			
Courses				
Title	Ту	ур	Hrs/wk	СР
Advanced Topics in Vibration (L174	l3) Pr	oject-/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 following	learning results		
Professional Competence				
Knowledge				
	 Students are able to reflect existing terms and concepts of Advance 			
	 Students are able to identify the need to develop and research new 	w terms and concepts in vibration	IS.	
Skills				
	 Students are able to apply existing methods and procesures of Adv 			
	 Students are able to develop novel methods and procedures for ac 	lvanced vibration problems.		
Personal Competence				
Social Competence				
	 Students can reach working results also in groups. 			
	 Students can present working results also in groups. 			
Autonomy				
	 Students are able to approach given research tasks individually 			
	 Students are able to identify and follow up novel research tasks 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	Mechatronics: Specialisation System Design: Elective Compulsory			
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elect	tive Compulsory		
	Mechatronics: Technical Complementary Course: Elective Compulso	ory		
	Theoretical Mechanical Engineering: Specialisation Product Develop	ment and Production: Elective	Compulsory	
	Theoretical Mechanical Engineering: Specialisation Simulation Tech	nology: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Simulation Tech	nology: Elective Compulsory		

Course L1743: Advanced Top	bics in Vibration
Тур	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	SoSe
	Advanced and Research Topics in Vibrations Rotor Dynamics Modal Analysis Model Order Reduction Stability of Periodic Solutions Random Vibrations
Literature	Aktuelle Veröffentlichungen / Recent research publications Bücher/Books: Gasch, Nordmann, Pfützner: Rotordynamik Gasch, Knothe, Liebich: Strukturdynamik

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 			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	 Students can explain humanoid robots 	-		
		zoncepts for different tasks in humanoid re	obotics.	
Skills	 Students acquire knowledge about sel 	ected aspects of humanoid robotics, base	ed on specified literature	
	 Students generalize developed results 			
	 Students practice to prepare and give 	a presentation		
Personal Competence				
Social Competence	 Students are capable of developing solutions in interdisciplinary teams and present them 			
	 They are able to provide appropriate f 	eedback and handle constructive criticism	n of their own results	
Autonomy				
Autonomy	 Students evaluate advantages and of 	drawbacks of different forms of present	ation for specific tasks	and select the be
	solution			
	 Students familiarize themselves with 	a scientific field, are able of introduce it	and follow presentation	ns of other studen
	such that a scientific discussion devel	ops		
Workload in Hours	Independent Study Time 32, Study Time in L	ecture 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and				
scale				
Assignment for the	Mechatronics: Specialisation Intelligent Syste	ems and Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design:	Elective Compulsory		
	Biomedical Engineering: Specialisation Artific	cial Organs and Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation Impla	nts and Endoprostheses: Elective Compul	sory	
	Biomedical Engineering: Specialisation Medio	cal Technology and Control Theory: Electiv	ve Compulsory	
	Biomedical Engineering: Specialisation Mana	gement and Business Administration: Elec	ctive Compulsory	
	Theoretical Mechanical Engineering: Speciali	sation Robotics and Computer Science: El	ective Compulsory	

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

Courses				
Title		Тур	Hrs/wk	СР
inear and Nonlinear System Ident	fication (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Classical control (frequency response)	onse, root locus)		
	State space methods			
	Discrete-time systems Linear algebra, singular value des	composition		
	 Linear algebra, singular value dec Basic knowledge about stochastic 			
		processes		
Educational Objectives	After taking part successfully, students I	have reached the following learning results		
Professional Competence				
Knowledge	 Students can explain the general 	I framework of the prediction error method	and its application to a	variety of linear a
	nonlinear model structures	in namework of the prediction error method	and its application to a	vallety of illiear a
		perceptron networks are used to model nonlin	ear dynamics	
		mate predictive control scheme can be based	-	
		pace identification and its relation to Kalman		
Skills	 Students are capable of applying 	g the predicition error method to the experi	mental identification of	linear and nonline
	models for dynamic systems	g the prediction error method to the experi	mental identification of	inear and normine
		g a nonlinear predictive control scheme based	on a neural network mo	del
		space algorithms to the experimental identific		
		ndard software tools (including the Matlab Syst		
Personal Competence	Chudanta and in mined and an			
Social Competence	Students can work in mixed groups on s	pecific problems to arrive at joint solutions.		
Autonomy	Students are able to find required inform	nation in sources provided (lecture notes, liter	rature, software docume	ntation) and use it
	solve given problems.			
Workload in Hours	Independent Study Time 62, Study Time	in Locture 29		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Co	ntrol and Power Systems Engineering: Elective	e Compulsory	
Following Curricula		Systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System De			
	Biomedical Engineering: Specialisation A	Artificial Organs and Regenerative Medicine: E	lective Compulsory	
	Biomedical Engineering: Specialisation I	mplants and Endoprostheses: Elective Compu	lsory	
	Biomedical Engineering: Specialisation N	Medical Technology and Control Theory: Comp	ulsory	
	Biomedical Engineering: Specialisation N	Management and Business Administration: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Cor	a Qualification: Elective Compulsory		

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

Module M0939: Contr	rol Lab A			
Courses				
Title		Тур	Hrs/wk	СР
Control Lab I (L1093)		Practical Course	1	1
Control Lab II (L1291)		Practical Course	1	1
Control Lab III (L1665)		Practical Course	1	1
Control Lab IV (L1666)		Practical Course	1	1
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	 State space methods 			
2	LQG control			
	H2 and H-infinity optimal control			
	uncertain plant models and robust co	ontrol		
	LPV control			
Educational Objectives	After taking part successfully, students hav	e reached the following learning results		
Professional Competence				
Knowledge				
2	Students can explain the difference b	petween validation of a control lop in simulatio	n and experimental v	validation
Skills	Students are capable of applying b	oasic system identification tools (Matlab Sys	tem Identification To	olbox) to identify
	dynamic model that can be used for	controller synthesis		
		software tools (Matlab Control Toolbox) for	the design and imp	lementation of LO
	controllers			
		software tools (Matlab Robust Control Toolbox)	for the mixed-sensit	ivity design and th
	implementation of H-infinity optimal			
		del uncertainty, and of designing and impleme	enting a robust contro	oller
		software tools (Matlab Robust Control Toolbox)		
	LPV gain-scheduled controllers		for the design and th	
	LFV gam-scheduled controllers			
Personal Competence				
Social Competence				
	Students can work in teams to condu	act experiments and document the results		
Autonomy				
Autonomy	Students can independently carry ou	t simulation studies to design and validate cor	ntrol loops	
Workload in Hours	Independent Study Time 64, Study Time in	Lecture 56		
Credit points				
Course achievement	None			
Examination	Written elaboration			
Examination duration and	1			
scale				
Assignment for the	Electrical Engineering: Specialisation Contro	ol and Power Systems Engineering: Elective Co	mpulsory	
Following Curricula			,	
	Mechatronics: Specialisation Intelligent Syst			
		lisation Robotics and Computer Science: Electi	ive Compulsory	

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

Module Manual M.Sc. "Mechatronics"

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

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

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

Modulo M0024, Softw	ore for Embedd	ad Systems				
Module M0924: Softw	are for Embedd	ed 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 F	lenner				
Admission Requirements	None					
Recommended Previous		de dave i e ad avec etter til		en el la the Claurence		
Knowledge	-			mming in the C language		
	-	e in software enginee	-			
	 Basic understar 	iding of assembly land	guage			
Educational Objectives	After taking part succe	essfully, students hav	e reached the follow	ng learning results		
Professional Competence						
Knowledge	Students know the ba	sic principles and pro	ocedures of software	engineering for embedded s	systems. They are	able to describe th
	usage and pros of e	event based program	mming using interru	pts. They know the comp	onents and func	tions of a concret
	microcontroller. The p	microcontroller. The participants explain requirements of real time systems. They know at least three scheduling algorithms f				
	real time operating sys	stems including their	pros and cons.			
Skills	Students build interru	pt-based programs f	for a concrete micro	controller. They build and u	se a preemptive	scheduler. They use
	peripheral components (timer, ADC, EEPROM) to realize complex tasks for embedded systems. To interface with ex					-
		components they utilize serial protocols.				
Personal Competence						
Social Competence						
Autonomy						
Workload in Hours	Independent Study Tir	ne 110, Study Time ir	n Lecture 70			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	No 10 %	Attestation				
Examination	Written exam					
Examination duration and	90 min					
scale						
Assignment for the	Computer Science: Sp	ecialisation I. Comput	ter and Software Eng	ineering: Elective Compulsor	У	
Following Curricula	Electrical Engineering:	Specialisation Inform	nation and Communio	cation Systems: Elective Com	pulsory	
	Information and Comn	nunication Systems: S	Specialisation Comm	unication Systems, Focus Sof	tware: Elective Co	ompulsory
	Mechatronics: Technic	al Complementary Co	ourse: Elective Comp	ulsory		
	Mechatronics: Speciali	sation Intelligent Syst	tems and Robotics: E	lective Compulsory		
	Mechatronics: Speciali	sation System Desigr	n: Elective Compulso	ŷ		
	Microelectronics and M	licrosystems: Special	isation Embedded Sv	stems: Elective Compulsory		

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

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

Courses						
Title		Тур	Hrs/wk	СР		
Compilers for Embedded Systems (L1692)	Lecture	3	4		
Compilers for Embedded Systems (L1693)	Project-/problem-based Learning	1	2		
Module Responsible	Prof. Heiko Falk					
Admission Requirements	None					
Recommended Previous	Module "Embedded Systems"					
Knowledge	C/C++ Programming skills					
Educational Objectives	After taking part successfully, students h	ave reached the following learning results				
Professional Competence						
Knowledge	The relevance of embedded systems inc	reases from year to year. Within such systems, the am	ount of softwa	re to be executed		
	embedded processors grows continuous	ly due to its lower costs and higher flexibility. Because	of the particu	lar application are		
		d and application-specific processors are deployed.				
		h have to generate code of highest quality. After the su				
	the students are able					
	 to illustrate the structure and organized 					
		diate representations of various abstraction levels, and				
	 to assess optimizations and their up 	underlying problems in all compiler phases.				
	The high demands on compilers for en	nbedded systems make effective code optimizations	mandatory. Th	ne students learn		
	particular,					
	 which kinds of optimizations are a 					
	how the translation from source co					
	which kinds of optimizations are applicable at the assembly code level,					
	how register allocation is performed, and					
	how memory hierarchies can be exploited effectively.					
	Since compilers for embedded systems of	ften have to optimize for multiple objectives (e.g., ave	rage- or worst-	case execution tin		
	energy dissipation, code size), the stude	nts learn to evaluate the influence of optimizations on t	hese different	criteria.		
Skills	After successful completion of the source	a students shall be able to translate bigh lovel program	a cada inta ma	china cada Thavu		
<i>SKIIIS</i>	After successful completion of the course, students shall be able to translate high-level program code into machine code. They will be analyzed to assess which kind of code optimization should be applied most effectively at which abstraction level (e.g., source of					
	be enabled to assess which kind of code optimization should be applied most effectively at which abstraction level (e.g., source or assembly code) within a compiler.					
	assembly code) within a complier.					
	While attending the labs, the students wi	ill learn to implement a fully functional compiler includi	ng optimizatior	ns.		
Personal Competence						
Social Competence	Students are able to solve similar problem	ms alone or in a group and to present the results accor	dingly.			
Autonomy	Students are able to acquire new knowle	dge from specific literature and to associate this knowl	edge with othe	r classes.		
	Independent Study Time 124, Study Time	e in Lecture 56				
Credit points						
Course achievement						
Examination						
Examination duration and	30 min					
scale		autor and Coffman Engineering Election Com-				
-		outer and Software Engineering: Elective Compulsory	loon			
Following Curricula	5 5 1	prmation and Communication Systems: Elective Compu	ізогу			
	Aircraft Systems Engineering: Core Quali	fication: Elective Compulsory ystems and Robotics: Elective Compulsory				
	Mechatronics: Specialisation Intelligent S Mechatronics: Specialisation System Des					
	Mechatronics: Specialisation System Des Mechatronics: Technical Complementary					
	meenacionics, recinical complementary	Course. Elective compuisory				

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

Course L1693: Compilers for	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	łeiko Falk	
Language	N	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

	J	ation in Medicine				
Courses						
Title			Тур	Hrs/wk	СР	
Robotics and Navigation in Medicir			Lecture	2	3	
Robotics and Navigation in Medicine (L0338)			Project Seminar Recitation Section (small)	2	2 1	
Robotics and Navigation in Medicin		actor	Recitation Section (smail)	1	T	
Module Responsible Admission Requirements		deler				
Recommended Previous						
Knowledge	 principles of m 	math (algebra, analysis/calcu	llus)			
	 principles of p 	programming, e.g., in Java or	C++			
	 solid R or Matl 	lab skills				
Educational Objectives	After taking part suc	ccessfully, students have read	ched the following learning results			
Professional Competence		· ·				
Knowledge	The students can ex	xplain kinematics and track	ing systems in clinical contexts and illu	strate systems and	their component	
	detail. Systems can	be evaluated with respect	to collision detection and safety and	regulations. Studen	ts can assess typ	
	systems regarding de	lesign and limitations.				
Skille	The students are abl	le to design and evaluate nav	vigation systems and robotic systems for	medical application	c	
SKIIIS	The students are abl	te to design and evaluate na	vigation systems and robotic systems for	medical application	3.	
Personal Competence						
		ole to grasp practical tasks i	in groups, develop solution strategies in	dependently, define	work processes	
	work on them collabo					
	The students are ab	ble to collaboratively organiz	ze their work processes and software so	olutions using virtua	I communication	
	software management tools.					
	The students can critically reflect on the results of other groups, make constructive suggestions for improvement, and al					
	incorporate them into their own work.					
Autonomy			dge and independently control their leas			
	manner to the other		evaluate the results achieved and prese	nt them in an appro	opriate argumenta	
		groups.				
		Time 110, Study Time in Lect	ture 70			
Credit points		Form	Description			
Course achievement	Yes 10 %	Written elaboration				
	Yes 10 %	Presentation				
Examination	Written exam					
Examination duration and	90 minutes					
scale						
Assignment for the	Computer Science: S	Specialisation II: Intelligence	Engineering: Elective Compulsory			
Following Curricula	Electrical Engineering	ng: Specialisation Medical Tec	chnology: Elective Compulsory			
	International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory					
	-		cialisation II. Process Engineering and Bio	technology: Elective	Compulsory	
		5 ,	and Robotics: Elective Compulsory			
	-		Organs and Regenerative Medicine: Election			
	5	5 1	and Endoprostheses: Elective Compulsor			
		ing. specialisation Medical I	echnology and Control Theory: Elective C	ompuisory		
	5	ring: Specialization Managem	ont and Rusiness Administration, Election	Compulsory		
	Biomedical Engineeri		ent and Business Administration: Elective Specialisation Product Development: Elective			
	Biomedical Engineeri Product Developmen	nt, Materials and Production:	Specialisation Product Development: Ele	ctive Compulsory		
	Biomedical Engineeri Product Developmen Product Developmen	nt, Materials and Production: nt, Materials and Production:		ctive Compulsory ulsory		

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

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

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

Courses									
Title		Тур	Hrs/wk	СР					
Lab Applied Dynamics (L1631)		Practical Course	2	2					
Applied Dynamics (L1630)		Lecture	4	4					
Module Responsible	Prof. Robert Seifried								
Admission Requirements	None								
Recommended Previous	Mathematics I, II, III, Mechanics I, II, III, IV	Mathematics I, II, III, Mechanics I, II, III, IV							
Knowledge	Numerical Treatment of Ordinary Differential Eq	uations							
Educational Objectives	After taking part successfully, students have rea	ached the following learning results							
Professional Competence									
Knowledge	Students can represent the most important me and have a good understanding of the main con		letion of the module	e Technical dynami					
Skills	Students are able								
	+ to think holistically								
	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multiboc systems								
	+ to describe dynamics problems mathematically								
	+ to investigate dynamics problems both exper	mentally and numerically							
Personal Competence									
Social Competence	Students are able to								
	+ solve problems in heterogeneous groups and	to document the corresponding results.							
Autonomy	Students are able to								
	+ assess their knowledge by means of exercises and experiments.								
	+ acquaint themselves with the necessary know	ledge to solve research oriented tasks.							
Workload in Hours	Independent Study Time 96, Study Time in Lect	ure 84							
Credit points	6								
Course achievement	Compulsory Bonus Form Yes None Subject theoretical practical work	Description andVersuche Fachlabor							
Examination	Written exam								
Examination duration and	90 min								
scale									
Assignment for the	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory							
Following Curricula	Mechatronics: Specialisation System Design: Ele	ective Compulsory							
	Theoretical Mechanical Engineering: Core Qualif	ication: Compulsory							

Course L1631: Lab Applied D	ynamics
Тур	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Marc-André Pick
Language	DE
Cycle	SoSe
	Practical exercises are performed in groups. The examples are taken from different areas of applied dynamics, such as numerical simulation, experimental validation and experimental vibration analysis.
Literature	Schiehlen, W.; Eberhard, P.: Technische Dynamik, 4. Auflage, Vieweg+Teubner: Wiesbaden, 2014.

Course L1630: Applied Dyna	mics
Тур	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Robert Seifried, Dr. Marc-André Pick
Language	DE
Cycle	SoSe
Content	 Modelling of Multibody Systems Basics from kinematics and kinetics Constraints Multibody systems in minimal coordinates State space, linearization and modal analysis Multibody systems with kinematic constraints Multibody systems as DAE Non-holonomic multibody systems Experimental Methods in Dynamics
Literature	Schiehlen, W.; Eberhard, P.: Technische Dynamik, 4. Auflage, Vieweg+Teubner: Wiesbaden, 2014. Woernle, C.: Mehrkörpersysteme, Springer: Heidelberg, 2011. Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.

Courses							
Title				Тур		Hrs/wk	СР
Embedded Systems (L0805)				Lecture		3	3
Embedded Systems (L2938)				Project-/	problem-based Learning	1	1
Embedded Systems (L0806)				Recitatio	n Section (small)	1	2
Module Responsible	Prof. Heiko Falk						
Admission Requirements	None						
	Computer Engineering	g					
Knowledge							
Educational Objectives	After taking part succ	essfully, students	have reached t	the following learning	ig results		
Professional Competence							
Knowledge	Embedded systems ca	an be defined as	nformation pro	cessing systems en	nbedded into enclosing	products. Thi	s course teaches
					nto these systems (not		
					mata, specification of	distributed sy	/stems, task grap
	specification of real-ti	me applications,	ranslations bet	ween different mod	els).		
	Another part covers	the hardware of	embedded sys	tems: Sonsors, A/D	and D/A converters,	real-time cap	able communicat
	hardware, embedded	processors, men	ories, energy	dissipation, reconfig	jurable logic and actua	ators. The cou	urse also features
	introduction into real	i-time operating	ystems, middle	eware and real-tim	e scheduling. Finally,	the implemen	tation of embed
	systems using hardwa	are/software co-d	esign (hardwar	e/software partitior	ing, high-level transfo	rmations of sp	pecifications, ener
	efficient realizations,	compilers for emb	edded process	ors) is covered.			
Chille	After beying attended	d the second stu	danta chall ha	abla ta vaaliza sina			
SKIIIS	After having attended the course, students shall be able to realize simple embedded systems. The students shall realize which						
	relevant parts of technological competences to use in order to obtain a functional embedded systems. In particular, they shall b able to compare different models of computations and feasible techniques for system-level design. They shall be able to judge i						
	which areas of embed				es for system-level des	agn. mey sna	
Personal Competence	which dreas of embed	laca system acsig	in specific fisits	exist.			
-	Students are able to s	solve similar prob	ems alone or in	a group and to pre	sent the results accord	linaly	
Social competence		forve similar prob		a group and to pre		inigiy.	
Autonomy	Students are able to a	acquire new know	edge from spec	cific literature and t	o associate this knowle	dge with othe	r classes.
Workload in Hours	Independent Study Tir	me 110 Study Ti	ne in Lecture 7	0			
	6	ine 110, Study In	The In Lecture 7	0			
Course achievement	Compulsory Bonus	Form	Des	cription			
course achievement	Yes 10 %	Subject theor	etical and				
		practical work					
Examination	Written exam						
Examination duration and	90 minutes, contents	of course and lab	s				
scale							
Assignment for the	General Engineering 9	Science (German	program, 7 sem	ester): Specialisatio	on Computer Science: (Compulsory	
Following Curricula	Computer Science: Sp	oecialisation I. Cor	nputer and Soft	ware Engineering:	Elective Compulsory		
	Electrical Engineering	: Core Qualification	n: Elective Con	npulsory			
	Engineering Science:	Specialisation Me	chatronics: Elec	tive Compulsory			
	Engineering Science:	Specialisation Ele	ctrical Engineer	ring: Elective Comp	ulsory		
	Aircraft Systems Engi	neering: Core Qua	lification: Elect	ive Compulsory			
	General Engineering S	Science (English p	rogram, 7 seme	ester): Specialisatio	n Mechatronics: Electiv	e Compulsory	
		Engineering: Core	Qualification: 0	Compulsory			
	Mechatronics: Special Mechatronics: Special	-	-				

Course L0805: Embedded Sy	stems			
Тур	Lecture			
Hrs/wk	3			
СР	3			
Workload in Hours	ndependent Study Time 48, 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 L2938: Embedded Sy	stems
Тур	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
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 Sy	urse L0806: Embedded Systems		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Heiko Falk		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title		Тур	Hrs/wk	СР
Machine Learning and Data Mining		Lecture	2	4
Machine Learning and Data Mining		Recitation Section (small)	2	2
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusStochastics			
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence		5 5		
Skills	can be improved by ensemble learning, reinforcement learning can also be expla Student derive decision trees and, in tu explain basic optimization techniques. T BME, MAP, ML, and EM algorithms for le know how to carry out Gaussian mixt machines, and name their basic applica and explain the basic components of t	tch different clustering techniques. They depict ho and they can summarize how this influences comp lined by students. Irrn, propositional rule sets from simple and static 'hey present and apply the basic idea of first-ord arning parameters of Bayesian networks and com ure learning. They can contrast kNN classifiers tion areas and algorithmic properties. Students c hose techniques. Students compare related maci fication. They can distinguish various ensemble	data tables and a c data tables and a er inductive leaning pare the different a , neural networks, an describe basic hine learning techr	theory. Algorithms for the able to name and g. Students apply the algorithms. They all and support vect clustering techniqu niques, e.g., k-mea
Personal Competence				
Personal Competence Social Competence				
Personal Competence Social Competence Autonomy				
Social Competence Autonomy	Independent Study Time 124, Study Tim	e in Lecture 56		
Social Competence Autonomy Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56		
Social Competence Autonomy Workload in Hours Credit points		e in Lecture 56		
Social Competence Autonomy Workload in Hours Credit points Course achievement	6 None	e in Lecture 56		
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	6 None	e in Lecture 56		
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	6 None Written exam	e in Lecture 56		
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	6 None Written exam 90 minutes	e in Lecture 56		
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	6 None Written exam 90 minutes Computer Science: Specialisation II: Inter International Management and Engineer	ligence Engineering: Elective Compulsory ing: Specialisation II. Information Technology: Elec	tive Compulsory	
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	6 None Written exam 90 minutes Computer Science: Specialisation II: Inter International Management and Engineer Mechatronics: Technical Complementary	ligence Engineering: Elective Compulsory ing: Specialisation II. Information Technology: Elec Course: Elective Compulsory	tive Compulsory	
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	6 None Written exam 90 minutes Computer Science: Specialisation II: Inter International Management and Engineer Mechatronics: Technical Complementary Mechatronics: Specialisation System Des	ligence Engineering: Elective Compulsory ing: Specialisation II. Information Technology: Elec Course: Elective Compulsory	tive Compulsory	

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

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

Module M1173: Appli	ed Statistics			
Courses				
Title	Тур		Hrs/wk	СР
Applied Statistics (L1584)	Lectu	re	2	3
Applied Statistics (L1586)	Project	ct-/problem-based Learning	2	2
Applied Statistics (L1585)	Recita	ation Section (small)	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of statistical methods			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following lear	rning results		
Professional Competence				
Knowledge	Students can explain the statistical methods and the conditions of thei	r 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	None			
Examination	Written exam			
Examination duration and	90 minutes, 28 questions			
scale				
Assignment for the	Mechanical Engineering and Management: Specialisation Management	: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective	Compulsory		
	Mechatronics: Specialisation System Design: Elective Compulsory			
	Mechatronics: Core Qualification: Elective Compulsory			
	Biomedical Engineering: Core Qualification: Compulsory			
	Product Development, Materials and Production: Core Qualification: Ele	ective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Te	chnology: Elective Compul	sory	

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

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

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

Courses					
Title		Тур	Hrs/wk	СР	
Formulas and Vehicles - Dynamics and Control of Autonomous Vehicles (L2869)		Integrated Lecture	1	1	
	n into Mobile Underwater Robotics (L1981)	Project-/problem-based Learning	4	5	
Module Responsible					
Admission Requirements	None				
Recommended Previous					
Knowledge	Numerical Treatment of Ordinary Differential Equati	ons			
	Control Systems Theory and Design				
Educational Objectives	After taking part successfully, students have reache	d the following learning results			
Professional Competence					
Knowledge	After successful completion of the module students demonstrate deeper knowledge and understanding in selected applicati areas of multibody dynamics and robotics				
Skills	Students are able				
	+ to think holistically				
	+ to independently, securly and critically analyze systems	and optimize basic problems of the dynam	ics of rigid a	nd flexible multibo	
	+ to describe dynamics problems mathematically				
	+ to implement dynamical problems on hardware				
Personal Competence					
Social Competence	Students are able to				
	+ solve problems in heterogeneous groups and to d	ocument the corresponding results and prese	ent them		
Autonomy	Students are able to				
	+ assess their knowledge by means of exercises and	d projects.			
	+ acquaint themselves with the necessary knowledge	ge to solve research oriented tasks.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture	70			
Credit points	6				
Course achievement	None				
Examination	Presentation				
Examination duration and	ТВА				
scale					
-	Mechatronics: Specialisation Intelligent Systems and				
Following Curricula	Mechatronics: Specialisation System Design: Electiv				
	Mechatronics: Core Qualification: Elective Compulso	ry			

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

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

Module M0832: Advar	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	NN			
Admission Requirements	None			
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear matrix	x inequalities		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follow	ing learning results		
Professional Competence				
Knowledge Skills	 Students can explain the advantages and shortcomings of They can explain the representation of nonlinear systems. They can explain how stability and performance condition. They can explain how gridding techniques can be used to They are familiar with polytopic and LFT representation associated with each of these model structures. Students can explain how graph theoretic concepts a systems. They can explain the convergence properties of first orde. They can explain analysis and synthesis conditions for for. Students can construct LPV models of nonlinear plan controllers; they can do this using polytopic, LFT or genere. They can use standard software tools (Matlab robust controllers for tools provided 	s in the form of quasi-LPV syst ns for LPV systems can be forr o solve analysis and synthesis ons of LPV systems and som re used to represent the co er consensus protocols rmation control loops involvin odel Predictive Control (MPC) nts and carry out a mixed- ral LPV models trol toolbox) for these tasks	sensitivity design	systems synthesis techniqu ology of multiage / agent models n of gain-schedule
Personal Competence	Students can design MPC controllers for linear and non-li	near systems using Matlab too	bls	
	Students can work in small groups and arrive at joint results.			
		cture notes, literature, softwa	re documentatior) and use it to sol
	given problems.			
	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the	Electrical Engineering: Specialisation Control and Power System	ns Engineering: Elective Comp	ulsory	
Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Comp	oulsory		
	Aeronautics: Core Qualification: Elective Compulsory			
	Mechatronics: Specialisation Intelligent Systems and Robotics: E	Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective Compulso	ry		
	Mechatronics: Core Qualification: Elective Compulsory			
	Biomedical Engineering: Specialisation Implants and Endoprost	heses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and	Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management and Busine	ess Administration: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation Artificial Organs and Rec	generative Medicine: Elective	Compulsory	
	Theoretical Mechanical Engineering: Specialisation Robotics and	d Computer Science: Elective (Compulsory	

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

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

Module M1748: Const	ruction Robotics
Courses	
Fitle Construction Robotics (L2867)	Typ Hrs/wk CP Project-/problem-based Learning 6 6
Module Responsible	
Admission Requirements	
Recommended Previous	
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Basics of robotics
	Applications in civil engineering
	Kinematics
	Kindidas
Skills	Use of specific hardware
	Development of software routines
	Python programming language
	Image processing
	Basics of localization (LIDAR, SLAM)
Personal Competence	
Social Competence	Teamwork
	Communication skills
Autonomy	Independent work
	Independent decisions
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and	ca. 10 Seiten
scale	
	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory
Following Curricula	
	Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory
	Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory
	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
	Mechatronics: Core Qualification: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L2867: Construction	Robotics		
Тур	Project-/problem-based Learning		
Hrs/wk	6		
CP	6		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Lecturer	f. Kay Smarsly, Jan Stührenberg, Mathias Worm		
Language	DE/EN		
Cycle	WiSe		
Content	 Introduction: Robotics in civil engineering Presentation of potential topics Programming of algorithms in Python Application of software systems: LINUX distribution, ROS, CloudCompare, Application of hardware systems: Petoi Bittle Dog, Raspberry Pi, Arduino, sensing Topics considered for robotics using the Petoi Bittle Dog: Movement Use of sensors (camera, infrared,) Data structures/data acquisition Programming Topics technically relevant to building inspection: Geodetic evaluations Image processing Localization 		
Literature	Bock/Linner: Construction Robotics Verl et al.: Soft Robotics		
	Pasquale: New Laws of robotics		

Courses					
Courses					
Title		Тур	Hrs/wk	CP	
Image Processing (L2443) Image Processing (L2444)		Lecture Recitation Section (small)	2	4 2	
	Drof Tabias Knonn	Nectation Section (Smail)	2	2	
Module Responsible	Prof. Tobias Knopp				
Admission Requirements	None				
Recommended Previous	Signal and Systems				
Knowledge	After the life manufacture of the standard state in the second	and the stall sectors becausing a second sec			
	After taking part successfully, students have reac	hed the following learning results			
Professional Competence					
Knowleage	The students know about				
	 visual perception 				
	 multidimensional signal processing 				
	 sampling and sampling theorem 				
	• filtering				
	 image enhancement 				
	edge detection				
	 multi-resolution procedures: Gauss and Lap 	lace pyramid, wavelets			
	image compression				
	image segmentation				
	 morphological image processing 				
Skills	The students can				
	analyze, process, and improve multidimensional image data				
	implement simple compression algorithms				
	 design custom filters for specific applicatio 	15			
Personal Competence					
Social Competence	Students can work on complex problems both ind	ependently and in teams. They can exchang	ge ideas with each	other and use th	
	individual strengths to solve the problem.				
Autonomy	Students are able to independently investigate a	complex problem and assess which compete	encies are require	d to solve it.	
Workload in Hours	Independent Study Time 124, Study Time in Lecto	ire 56			
Credit points					
Course achievement					
Examination					
Examination duration and	90 min				
scale	50 mm				
	Data Science: Core Qualification: Elective Comput	sorv			
-	Data Science: Specialisation I. Mathematics/Comp	•			
· · · · · · · · · · · · · · · · · · ·	Data Science: Specialisation II. Computer Science				
	Data Science: Specialisation IV. Special Focus Are				
	Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory				
	Electrical Engineering: Specialisation Information and Communication Systems: Elective Compusory				
	Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Software and Sign				
	Processing: Elective Compulsory				
	Information and Communication Systems: Special	isation Communication Systems, Focus Sigr	al Processing: Ele	ctive Compulsory	
	International Management and Engineering: Spec	alisation II. Information Technology: Elective	e Compulsory		
	Mechatronics: Specialisation Intelligent Systems a	nd Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Design: Elec	ive Compulsory			
	Mechatronics: Core Qualification: Elective Compu	sory			
	Microelectronics and Microsystems: Specialisation	Communication and Signal Processing: Elec	ctive Compulsory		
	Theoretical Mechanical Engineering: Specialisatio	Bobotics and Computer Science: Elective (Compulsory		

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

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

Courses					
Title		Тур	Hrs/wk	СР	
Digital Signal Processing and Digital Filters (L0446)		Lecture	3	4	
Digital Signal Processing and Digita		Recitation Section (large)	2	2	
Module Responsible	Prof. Gerhard Bauch				
Admission Requirements	None				
Recommended Previous	Mathematics 1-3				
Knowledge	Signals and Systems				
	 Fundamentals of signal and system 	theory as well as random processes.			
	Fundamentals of spectral transform	s (Fourier series, Fourier transform, Laplace tra	nsform)		
	After taking part successfully, students ha	ve reached the following learning results			
Professional Competence					
Knowledge		algorithms of digital signal processing. They ar			
	-	scribe and analyse signals and systems in tim	-	-	
		entify and assess important properties inclu pefficients and signals. They are familiar with			
				-	
	perform traditional and parametric methods of spectrum estimation, also taking a limited observation window into				
	The students are familiar with the contents of lecture and tutorials. They can explain and apply them to new problems.			problems.	
Skills	The students are able to apply methods of digital signal processing to new problems. They can choose and parameterize suitable				
	filter striuctures. In particular, the can des	ign adaptive filters according to the minimum i	cording to the minimum mean squared error (MMSE) criterion ar		
	develop an efficient implementation, e.g. based on the LMS or RLS algorithm. Furthermore, the students an				
	methods of spectrum estimation and to ta	methods of spectrum estimation and to take the effects of a limited observation window into account.			
Personal Competence					
Social Competence	The students can jointly solve specific pro	olems.			
Autonomy	The students are able to acquire relev	ant information from appropriate literature s	ources They can	control their level	
Autonomy		lving tutorial problems, software tools, clicker s	-		
		5 · · · P · · · · · · · · · · · · · · ·			
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70			
Credit points					
Course achievement	None				
Examination	Written exam				
Examination duration and	90 min				
scale					
-		rol and Power Systems Engineering: Elective Co			
Following Curricula		sation II. Engineering Science: Elective Compuls			
	Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory				
		Specialisation Mechatronics: Elective Compulso	ory		
	Mechatronics: Specialisation Intelligent Sy				
	Mechatronics: Core Qualification: Elective				
		lisation Communication and Signal Processing:		у	
	i neoretical Mechanical Engineering: Speci	alisation Robotics and Computer Science: Electi	ve 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	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	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 M1552: Adva	nced Machine Learning				
-	-				
Courses					
Title		Тур	Hrs/wk	СР	
Advanced Machine Learning (L2322 Advanced Machine Learning (L2322		Lecture Recitation Section (small)	2	3 3	
		Recitation Section (Small)	Z	5	
Module Responsible					
Admission Requirements	None				
Recommended Previous	1. Mathematics I-III				
Knowledge	2. Numerical Mathematics 1/ Numerics				
	3. Programming skills, preferably in Python				
Educational Objectives	After taking part successfully, students have rea	ched the following learning results			
Professional Competence	5 p				
•	Students are able to name, state and classify sta	ate-of-the-art neural networks and their corre	esponding mathe	matical basics. The	
	can assess the difficulties of different neural net				
Skills	Students are able to implement, understand, and, tailored to the field of application, apply neural networks.				
Personal Competence		,			
Social Competence	Students can				
,					
	develop and document joint solutions in small teams;form groups to further develop the ideas and transfer them to other areas of applicability;				
	 form a team to develop, build, and advance 	e a software library.			
Autonomy	Students are able to				
	 correctly assess the time and effort of self 	-defined work:			
	 assess whether the supporting theoretical 		dividually or in a	team;	
	 define test problems for testing and expansion 				
	assess their individual progess and, if nece	essary, to ask questions and seek help.			
Workload in Hours	Independent Study Time 124, Study Time in Lect	rure 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	25 min				
scale					
Assignment for the	Computer Science: Specialisation III. Mathematic	s: Elective Compulsory			
Following Curricula	Data Science: Core Qualification: Compulsory				
	Computer Science in Engineering: Specialisation	III. Mathematics: Elective Compulsory			
	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Design: Elec	ctive Compulsory			
	Mechatronics: Core Qualification: Elective Compu	llsory			
	Technomathematics: Specialisation I. Mathemati	cs: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation	on Robotics and Computer Science: Elective O	Compulsory		

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

Course L2323: Advanced Ma	urse L2323: Advanced Machine Learning				
Тур	Recitation Section (small)				
Hrs/wk	2				
CP	3				
Workload in Hours	dent Study Time 62, Study Time in Lecture 28				
Lecturer	s-Peter Zemke				
Language	1				
Cycle	WiSe				
Content	interlocking course				
Literature	See interlocking course				

Module M1596: Engin	eering Haptic S	Systems						
Courses								
Title					Тур		Hrs/wk	СР
Haptic Technology for Human-Machine-Interfaces (HMI) (L2439)				Lecture		4	3	
Haptic Technology for Human-Mach	hine-Interfaces (HMI) (L28	359)			Project-/problem-base	d Learning	2	3
Module Responsible	Prof. Thorsten Kern							
Admission Requirements	None							
Recommended Previous	We recommend know	ledae in the	areas of ge	neral engineering	sciences. mechatroni	ics and/or	control-engin	eering. However a
		-	-				-	-
	the content properly.			<u> </u>	,	,,.		
Educational Objectives		essfully stud	lents have re	eached the following	a learning results			
Professional Competence	, iter taking part sace	coording, ocur			ig learning results			
	This course is an inte							
	scratch. It covers a p							
	with consideration or							
	existing haptic applications and research in that field with many examples. This is supported by on-site experiments in the							
	laboratories of M-4.							
	 Motivation and 	application of	of haptic syst	tems				
	Haptic perception							
	The role of the user in direct system interaction							
	Development of haptic systems							
	Identification of requirements							
	System-structure and control							
	 Kinematic fund 							
	Actuation & Sensors technology for haptic applications							
	Control and system-design aspects							
	Fundamental considerations in simulating haptics							
				5				
Skills	s Executing the course the competency will be developed to apply the general engineering capabilities of the individual course							
	towards the design and application of active haptic systems. The resulting competencies will open an entry into specialize							
	position in avionic-ind	ustries, auto	motive-indus	stry and consumer	-device-development			
Personal Competence								
Social Competence	As a side-effect this	module tead	ches basics	of a general desig	gn for human-machir	ne-interface	es, independe	ent from the spec
	application of "haptic	s". It teache	s methods t	o execute user-st	udies, judge on user-	feedback a	and how to d	eal with soft desig
	requirements which a	re common v	when dealing	y with subjective p	erception.			
Autonomy	Independent design-c	apability of h	naptic systen	ns, general compe	tency in engineering	from a des	ign-perspectiv	/e
Workload in Hours	Independent Study Ti	me 96, Study	/ Time in Lec	ture 84				
Credit points	6							
Course achievement	Compulsory Bonus	Form		Description				
	Yes 20 %	Subject 1	theoretical	andDurchführung	von Laborversuchen	I		
		practical w	ork					
Examination	Subject theoretical an	d practical w	/ork					
Examination duration and	30 min							
scale								
Assignment for the	Mechatronics: Special	isation Intell	igent System	ns and Robotics: El	ective Compulsory			
Following Curricula	Mechatronics: Special	isation Syste	m Design: E	lective Compulsor	/			
-	Mechatronics: Core Q		-					
	Theoretical Mechanica							

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

course reconnection	ise 22055. haptic recimology for human-machine-interfaces (mm)			
Тур	ct-/problem-based Learning			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	ten Kern			
Language				
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

Courses					
Title		Тур	Hrs/wk	СР	
Mathematical Image Processing (L	0991)	Lecture	3	4	
Mathematical Image Processing (Li		Recitation Section (small)	1	2	
Module Responsible	Prof. Marko Lindner				
Admission Requirements	None				
Recommended Previous					
Knowledge					
	Linear Algebra: eigenvalues, least	squares solution of a linear system			
Educational Objectives	After taking part successfully, students h	ave reached the following learning results			
Professional Competence					
-	Students are able to				
	characterize and compare diffusion				
	explain elementary methods of im-				
	explain methods of image segmen				
	 sketch and interrelate basic concerning 	ots of functional analysis			
Skills	Students are able to				
	implement and apply elementary methods of image processing				
	 explain and apply modern method. 	s of image processing			
Personal Competence					
Social Competence	Students are able to work together i	n heterogeneously composed teams (i.e., team	ns from different	study programs a	
	background knowledge) and to explain th	eoretical foundations.			
A					
Autonomy		their understanding of complex concepts on their	r own. They can sp	pecify open questic	
	precisely and know where to get h	elp in solving them.			
	Students have developed sufficient	nt persistence to be able to work for longer peri	ods in a goal-orier	nted manner on ha	
	problems.				
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56			
Credit points					
Course achievement					
Examination					
Examination duration and					
scale					
Assignment for the		- General Bioprocess Engineering: Elective Compu	llsory		
Following Curricula			lisory		
. eenning curricula		lisation III. Mathematics: Elective Compulsory			
		tion Computational Methods in Biomedical Imaging	g: Compulsory		
		ystems and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Desi				
	Mechatronics: Core Qualification: Elective	Compulsory			
	Technomathematics: Specialisation I. Mat	thematics: Elective Compulsory			
		cialisation Robotics and Computer Science: Electiv	e Compulsory		

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

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

Module M0629: Intelli	igent Autonomous Agents and (Cognitive Robotics		
Courses				
Title		Тур	Hrs/wk	СР
Intelligent Autonomous Agents and	Cognitive Robotics (L0341)	Lecture	2	4
Intelligent Autonomous Agents and	Cognitive Robotics (L0512)	Recitation Section (small)	2	2
Module Responsible	Rainer Marrone			
Admission Requirements	None			
Recommended Previous	Vectors, matrices, Calculus			
Knowledge				
Educational Objectives	After taking part successfully, students have i	reached the following learning results		
Professional Competence				
	Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent desi (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperatic can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in re- world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoni formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequent settings, with and with complete access to the state of the environment. In this context, students can describe techniques is solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of informatic Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achievi desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different typ of equilibria, social choice functions, voting protocol, and mechanism design techniques. Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesi networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and appl different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute t best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilib states,e.g., Nash equilibria. For multi-agent decision making students will apply different voting protocols and compare and expla the results.			
Personal Competence			To allah	
Social Competence	Students are able to discuss their solutions to	problems with others. They communicate in	Ligion	
Autonomy	Students are able of checking their understan	nding of complex concepts by solving varaints	of concrete proble	ms
Workload in Hours	Independent Study Time 124, Study Time in L	Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
	Computer Science: Specialisation II: Intelligen	ce Engineering: Elective Compulsory		
Following Curricula	5 5 5		tive Compulsory	
	Mechatronics: Specialisation Intelligent System			
	Mechatronics: Core Qualification: Elective Cor			
	Biomedical Engineering: Specialisation Artifici		e Compulsory	
	Biomedical Engineering: Specialisation Implar			
	Biomedical Engineering: Specialisation Medica			
	Biomedical Engineering: Specialisation Manag			
	Theoretical Mechanical Engineering: Specialis	Sation Robotics and Computer Science: Electiv	e Compulsory	

Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	 Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements - chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, produce 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-cas complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be direct perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markc 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, inc
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 1 11, 13-17 Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005
	 Probabilistic Robotics, Thirdi, S., Burgard, W., Pox, D. Mill Press 2003 Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridg University Press, 2009

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

Courses						
Title		Тур	Hrs/wk	СР		
ntelligent Systems in Medicine (L0	331)	Lecture	2	3		
ntelligent Systems in Medicine (L0		Project Seminar	2	2		
ntelligent Systems in Medicine (L0	333)	Recitation Section (small)	1	1		
Module Responsible	Prof. Alexander Schlaefer					
Admission Requirements	None					
Recommended Previous	 principles of math (algebra, analysis/calculus) 	5)				
Knowledge	 principles of stochastics 	,				
	 principles of programming, Java/C++ and R/I 	Matlab				
	 advanced programming skills 					
Educational Objectives	After taking part successfully, students have reache	ed the following learning results				
Professional Competence						
Knowledge	The students are able to analyze and solve clinica	I treatment planning and decision suppo	rt problems using	methods for sear		
	optimization, and planning. They are able to explai	n methods for classification and their res	pective advantage	es and disadvanta		
	in clinical contexts. The students can compare diffe	erent methods for representing medical k	nowledge. They c	an evaluate meth		
	in the context of clinical data and explain challeng	ges due to the clinical nature of the data	and its acquisitio	n and due to priv		
	and safety requirements.					
Skills	The students can give reasons for selecting and a	dapting methods for classification, regre	ssion, and predict	ion. They can ass		
Skiis	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can asse the methods based on actual patient data and evaluate the implemented methods.					
Personal Competence						
Social Competence	The students are able to grasp practical tasks in	groups, develop solution strategies inde	pendently, define	work processes a		
	work on them collaboratively.					
	The students can critically reflect on the results of other groups, make constructive suggestions for improvement and a					
	incorporate them into their own work.					
Autonomy	The students can assess their level of knowledge a		critically evaluate	e the results achie		
	and present them in an appropriate argumentative manner to the other groups.					
	Independent Study Time 110, Study Time in Lectur	e 70				
Credit points	6	Description				
Course achievement	Compulsory Bonus Form Yes 10 % Written elaboration	Description				
	Yes 10 % Presentation					
Examination						
	90 minutes					
Examination duration and scale	90 minutes					
	Computer Science: Specialisation II: Intelligence En	cincering, Elective Compulsory				
-						
Following Curricula	Data Science: Specialisation III. Applications: Elective Compulsory Data Science: Specialisation IV. Special Focus Area: Elective Compulsory					
	Electrical Engineering: Specialisation Medical Techr					
	Interdisciplinary Mathematics: Specialisation Comp		Compulsory			
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory					
	Biomedical Engineering: Specialisation Artificial Org	•	Compulsory			
	Biomedical Engineering: Specialisation Implants an	-				
	Biomedical Engineering: Specialisation Managemer		ompulsory			
	Biomedical Engineering: Specialisation Medical Tec					

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

Course L0334: Intelligent Sy	urse L0334: Intelligent Systems in Medicine		
Тур	Project Seminar		
Hrs/wk	2		
CP	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	rrse L0333: Intelligent Systems in Medicine		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Alexander Schlaefer		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title		Tree	Line (mile	CD.
Flexible Multibody Systems (L1632)		Typ Lecture	Hrs/wk 2	CP 3
Optimization of dynamical systems		Lecture	2	3
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous				
Knowledge	Mathematics I, II, III			
5	Mechanics I, II, III, IV			
	 Simulation of dynamical Systems 			
Educational Objectives	After taking part successfully, students have react	hed the following learning results		
Professional Competence		5 5		
	Students demonstrate basic knowledge and und	lerstanding of modeling, simulation	n and analysis of comp	lex rigid and flexib
5	multibody systems and methods for optimizing dy			5
Skills	Students are able			
	+ to think holistically			
	the independent of a state and with a line of the		the domenties of similar	
	+ to independently, securly and critically analyz	e and optimize basic problems of	the dynamics of rigid a	nd flexible multibo
	systems			
	+ to describe dynamics problems mathematically			
	+ to optimize dynamics problems			
	+ to optimize dynamics problems			
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous groups and to	document the corresponding result	·c	
	r solve problems in neterogeneous groups and te	document the corresponding result		
Διιτοροφγ	Students are able to			
Autonomy				
	+ assess their knowledge by means of exercises.			
	+ acquaint themselves with the necessary knowle	dge to solve research oriented task	s.	
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ire 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and				
scale				
	Aircraft Systems Engineering: Core Qualification:	Elective Compulsory		
Following Curricula	Aeronautics: Core Qualification: Elective Compulse			
-	Mechatronics: Specialisation Intelligent Systems a	•		
	Mechatronics: Specialisation System Design: Elect	ive Compulsory		
	Mechatronics: Core Qualification: Elective Comput	•		
	Product Development, Materials and Production: 0	Core Qualification: Elective Compuls	ory	
	Theoretical Mechanical Engineering: Core Qualific	ation: Elective Compulsory		

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

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

Module M0720: Matri	x Algorithms			
Courses				
Title		Тур	Hrs/wk	СР
Matrix Algorithms (L0984)		Lecture	2	3
Matrix Algorithms (L0985)		Recitation Section (small)	2	3
Module Responsible	Dr. Jens-Peter Zemke			
Admission Requirements	None			
Recommended Previous	Mathematics I - III			
Knowledge	Numerical Mathematics 1/ Numerics			
	Basic knowledge of the programming I	anguages Matlab and C		
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	1. name, state and classify state-of-the-a	rt Krylov subspace methods for the solution of	of the core problem	ns of the engineerin
	sciences, namely, eigenvalue problem	s, solution of linear systems, and model reduct	ion;	
	2. state approaches for the solution of ma	atrix equations (Sylvester, Lyapunov, Riccati).		
Skills	Students are capable to			
Skiils				
	1. implement and assess basic Krylov su	bspace methods for the solution of eigenvalu	e problems, linear	systems, and mod
	reduction;			
		are with respect to computing time, stability, a	nd domain of appli	icability;
	adapt the approaches learned to new,	unknown types of problem.		
Personal Competence				
Social Competence	Students can			
	 develop and document joint solutions 	n small teams		
		as and transfer them to other areas of applicat	oility.	
	 form a team to develop, build, and adv 		,	
Autonomy	Students are able to			
	correctly assess the time and effort of	self-defined work;		
		ical and practical excercises are better solved	individually or in a	team;
	define test problems for testing and ex	panding the methods;		
	assess their individual progess and, if	necessary, to ask questions and seek help.		
Workload in Hours	Independent Study Time 124, Study Time in	_ecture 56		
Credit points				
Course achievement				
Examination				
Examination duration and				
scale				
	Computer Science: Specialisation III. Mathem	atics: Elective Compulsory		
Following Curricula				
	Data Science: Specialisation I. Mathematics:	Elective Compulsory		
	Mechatronics: Specialisation Intelligent Syste	ms and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design:	Elective Compulsory		
	Mechatronics: Core Qualification: Elective Con			
	Technomathematics: Specialisation I. Mathem			
	Theoretical Mechanical Engineering: Specialis	sation Simulation Technology: Elective Compute	sory	

Course L0984: Matrix Algorit	hms
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	 Part A: Krylov Subspace Methods: Basics (derivation, basis, Ritz, OR, MR) Arnoldi-based methods (Arnoldi, GMRes) Lanczos-based methods (Lanczos, CG, BiCG, QMR, SymmLQ, PvL) Sonneveld-based methods (IDR, BiCGStab, TFQMR, IDR(s)) Part B: Matrix Equations: Sylvester Equation Lyapunov Equation Algebraic Riccati Equation
Literature	 Skript (224 Seiten) Ergänzend können die folgenden Lehrbücher herangezogen werden: Saad, Yousef. Numerical methods for large eigenvalue problems: revised edition. Society for Industrial and Applied Mathematics, 2011. Saad, Yousef. Iterative methods for sparse linear systems. Society for Industrial and Applied Mathematics, 2003. Van der Vorst, Henk A. Iterative Krylov methods for large linear systems. No. 13. Cambridge University Press, 2003. Liesen, Jörg, and Zdenek Strakos. Krylov subspace methods: principles and analysis. Oxford University Press, 2013.

Course L0985: Matrix Algorit	Course L0985: Matrix Algorithms	
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Jens-Peter Zemke	
Language	DE/EN	
Cycle	WiSe	
Content		
Literature	Siehe korrespondierende Vorlesung	

ourses						
itle				Тур	Hrs/wk	СР
ptics for Engineers (L2437)				Lecture	3	3
ptics for Engineers (L2438)			1	Project-/problem-based Learning	3	3
Module Responsible	Prof. Thorsten Kern					
Admission Requirements	None					
Recommended Previous	- Basics of physics					
Knowledge						
Educational Objectives	After taking part succ	essfully, students have r	reached the following	g learning results		
Professional Competence						
Knowledge	Teaching subject ist t	he design of simple optic	cal systems for illum	ination and imaging optics		
		r optical systems and lig				
		k-bodies, color-perception				
	 Eight-Sources t Photometrics 	und their characterization	n			
	 Protometrics Ray-Optics 					
	, i					
	Matrix-Optics Stops, Pupils and Windows					
	 Light-field Tech 					
	Introduction to					
	Introduction to					
		5 1 5				
Skills	Understandings of opt	tics as part of light and e	electromagnetic spec	ctrum. Design rules, approach t	o designing o	ptics
Personal Competence						
Social Competence						
Autonomy						
Workload in Hours	Independent Study Ti	me 96, Study Time in Le	cture 84			
Credit points						
Course achievement	Compulsory Bonus	Form	Description			
	Yes None	Subject theoretical	andTeilnahme an	Laborübungen und Simulation		
		practical work				
Examination	Oral exam					
Examination duration and	30 min					
scale						
Assignment for the	Electrical Engineering	: Specialisation Microwa	ve Engineering, Opti	cs, and Electromagnetic Comp	atibility: Electi	ive Compulsory
Following Curricula	Mechatronics: Special	lisation Intelligent Syster	ms and Robotics: Ele	ctive Compulsory	-	
-		lisation System Design: I				
	Mechatronics: Core Q	ualification: Elective Con	npulsory			

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

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

Courses						
Title		Тур	Hrs/wk	СР		
ndustrial Process Automation (L03	44)	Lecture	2	3		
Industrial Process Automation (L03	45)	Recitation Section (small)	2	3		
Module Responsible	Prof. Alexander Schlaefer					
Admission Requirements	None					
Recommended Previous	mathematics and optimization methods					
Knowledge	principles of automata					
	principles of algorithms and data structures					
	programming skills					
Educational Objectives	After taking part successfully, students have	reached the following learning results				
Professional Competence	After taking part successivily, students have	reached the following learning results				
-	The students can evaluate and assess discre	ete event systems. They can evaluate propertie:	of processos and	ovolain mothods		
Kilowieuge		methods for process modelling and select an a				
		the context of actual problems and give a de		-		
		ethods. The students can relate process auto				
		ke 'cyberphysical systems' and 'industry 4.0'.				
	sensor systems as well as to recent topics in	te cyberphysical systems and industry 4.0.				
Skille	The students are able to develop and mode	h processes and evaluate them accordingly. This	c involvoc taking i	into account ontir		
SKIIIS		el processes and evaluate them accordingly. Thi	s involves taking i	into account opti		
	scheduling, understanding algorithmic comp	nexity, and implementation using PLCs.				
Personal Competence						
Social Competence	The students can independently define work	processes within their groups, distribute tasks	within the group a	nd develop soluti		
	collaboratively.					
Autonomy	The students are able to assess their level of	f knowledge and to document their work results	adequately.			
Workload in Hours	Independent Study Time 124, Study Time in	Locturo E6				
Credit points		Lecture 50				
Course achievement		Description				
course acmevement	No 10 % Excercises					
Examination	Written exam					
Examination duration and	90 minutes					
scale						
	Bioprocess Engineering: Specialisation A - G	eneral Bioprocess Engineering: Elective Compute	sorv			
-		alisation Chemical Process Engineering: Elective	-			
	Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory					
	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory					
			Subory			
	Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory					
		Specialisation II. Product Development and Proc		ompulsory		
	Aeronautics: Core Qualification: Elective Con		Laction. Elective C	5puisoi y		
	-	pecialisation Mechatronics: Elective Compulsory	,			
	Mechanical Engineering and Management: S Mechatronics: Specialisation Intelligent Syste					
	Mechatronics: Specialisation Intelligent Syste Mechatronics: Core Qualification: Elective Co					
		isation Robotics and Computer Science: Elective	Compulsory			
			compuisory			
	Process Engineering: Specialisation Chemica	a modess engineering. Elective Compuisory				
	Process Engineering: Specialisation Process	Engineering: Elective Compulsory				

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

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

Courses							
Title					Тур	Hrs/wk	СР
Control Lab V (L1667)					Practical Course	1	1
Control Lab VI (L1668)					Practical Course	1	1
Module Responsible	NN						
Admission Requirements	None						
Recommended Previous							
Knowledge		itate space method	5				
		QG control					
		12 and H-infinity op					
		•	els and robust contro				
	• [LPV control					
Educational Objectives	After tal	king part successfu	ly, students have rea	ached the followin	g learning results		
Professional Competence							
Knowledge							
	• 5	itudents can explair	the difference betw	een validation of	a control lop in simulati	on and experimental	validation
Skills							
	• Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a						
		-	can be used for cont	-			
	• T	hey are capable o	f using standard sof	ftware tools (Matl	ab Control Toolbox) fo	r the design and imp	plementation of L
	-	ontrollers					
			-		Robust Control Toolbox	<) for the mixed-sensi	tivity design and t
	ir	mplementation of H	-infinity optimal cont	rollers			
	• T	hey are capable of	representing model	uncertainty, and o	f designing and implem	nenting a robust contr	oller
	• T	hey are capable of	using standard softw	are tools (Matlab	Robust Control Toolbox) for the design and th	ne implementation
	L	PV gain-scheduled	controllers				
Personal Competence							
Social Competence							
Social Competence	• S	tudents can work ir	teams to conduct e	xperiments and d	ocument the results		
Autonomy	• S	tudents can indepe	ndently carry out sin	nulation studies to	design and validate co	ontrol loops	
Workload in Hours Credit points		ident Study Time 3.	2, Study Time in Lect	ture 28			
Course achievement							
Examination		elaboration					
Examination Examination duration and							
scale							
		al Engineering: Spe	cialisation Control an	d Power Systems	Engineering: Elective C	Compulsory	
Following Curricula					Lighteening. Liective C		
ronowing curricula			n Intelligent Systems	-	ective Compulsory		
	Mechall	onics. specialisatio	in memgent systems	and Robotics. El	cuve compuisory		

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

Course L1668: Control Lab V	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

-							
Courses							
Title Advanced Topics in Control (L1803)					Typ Seminar	Hrs/wk 2	CP 2
Module Responsible	NN				Schiller	L	L
Admission Requirements							
Recommended Previous Knowledge	•	Introduction to Control theory a optimal and rob	ind design				
Educational Objectives	After t	taking part succe	ssfully, students l	have reached the	e following learning results		
Professional Competence Knowledge			plain modern con o apply basic con		different tasks		
Skills	•	Students genera	-	esults and presen	ts of modern control, base t them to the participants ion	d on specified literature	
Personal Competence Social Competence			pable of developir provide appropri		present them d handle constructive critic	ism of their own results	
Autonomy		solution Students familia		with a scientific	f different forms of prese		
Workload in Hours	Indepe	endent Study Tir	ne 32, Study Time	e in Lecture 28			
Credit points	2						
Course achievement	None						
Examination	Preser	ntation					
Examination duration and	90 mii	n					
scale							
Assignment for the	Mecha	atronics: Speciali	sation Intelligent s	Systems and Rot	otics: Elective Compulsory		
Following Curricula		-	sation System De alification: Electiv	-	mpulsory		

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

Courses						
Title		Тур	Hrs/wk	СР		
Fundamentals of Maintenance, Rej	pair and Overhaul (MRO) (L3160)	Lecture	3	4		
Fundamentals of Maintenance, Re	pair and Overhaul (MRO) (L3161)	Recitation Section (large)	1	2		
Module Responsible	rof. Gerko Wende					
Admission Requirements	None					
Recommended Previous	We recommend knowledge in the areas of general	engineering sciences, aeronautics and ai	rcraft systems er	ngineering. Technio		
Knowledge	fields like mechanical engineering, mechatronics	and production engineering will be intro	duced into the	elevant aeronauti		
	content.					
Educational Objectives	After taking part successfully, students have reache	ed the following learning results				
Professional Competence						
Knowledge	The students are able to describe fundamental corr	elations for the sustainable operation of te	chnical assets ar	nd to identify solut		
	approaches for complex optimization problems.					
CI-III-	The shudeness enclosed to exclude a second state					
SKIIIS	s The students are enabled to apply the general engineering capabilities of the individual course towards the optimization of the sustainability in operation of technical assets. The resulting competencies will open an entry into positions in the development					
	production and technical operation of sustainable products in the mobility and engineering industries.					
	production and technical operation of sustainable p	roducts in the mobility and engineering in	uustries.			
Personal Competence						
Social Competence	The students are able to work in mixed groups with a clear focus on the approached solutions by respecting the compl					
	environment of multiple stakeholders.					
Autonomy	The students are enabled to find solutions for c	ntimization problems and to take requ	ired decision for	the accessment		
Autonomy	determining factors independently.	primization problems and to take requ	lifed decision for	the assessment		
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	30 min					
scale						
Assignment for the	Aircraft Systems Engineering: Core Qualification: Ele	ective Compulsory				
Following Curricula	Aeronautics: Core Qualification: Elective Compulsor	У				
	Mechatronics: Specialisation Intelligent Systems and	d Robotics: Elective Compulsory				
	Mechatronics: Specialisation System Design: Elective					
	Mechatronics: Core Qualification: Elective Compulso	,				
	Product Development, Materials and Production: Sp					
	Product Development, Materials and Production: Sp		-			
	Product Development, Materials and Production: Sp					
	Theoretical Mechanical Engineering: Specialisation					
	Theoretical Mechanical Engineering: Specialisation	Aircratt Systems Engineering: Elective Cor	npulsory			

Course L3160: Fundamentals	s of Maintenance, Repair and Overhaul (MRO)
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Gerko Wende
Language	DE
Cycle	WiSe
Content	Fundamentals for the sustainable operation of technical assets by means of maintenance, repair and overhaul (MRO):
	 Life cycle analytics Material circularity and service products Rules and regulations Processes and production methods Tools and technologies Data handling and usage Design for maintenance Self-healing technical systems
Literature	•

Course L3161: Fundamentals	urse L3161: Fundamentals of Maintenance, Repair and Overhaul (MRO)			
Тур	Recitation Section (large)			
Hrs/wk	1			
CP	2			
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14			
Lecturer	Prof. Gerko Wende			
Language	DE			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

Specialization System Design

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

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

Module M0752: Nonli	near Dynamics			
Courses				
Title Nonlinear Dynamics (L0702)		Typ Integrated Lecture	Hrs/wk 4	CP 6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusLinear AlgebraEngineering Mechanics			
Educational Objectives	After taking part successfully, students hav	e reached the following learning results		
Professional Competence				
Knowledge	concepts.	terms and concepts in Nonlinear Dynamics and and methods of modeling and analysis for non	·	
Skills		nethods and procesures of Nonlinear Dynamics nethods and procedures for nonlinear dynamic		
Personal Competence Social Competence Autonomy	Students are able to approach given	onlinear dynamics also in groups. dures for problems of nonlinear dynamical syst research tasks on the basis of given methods ow up novel research tasks by themselves.		
		n Lecture 56		
Credit points				
Course achievement Examination	None Written exam			
Examination Examination duration and				
scale	2 110013			
	Aircraft Systems Engineering: Core Qualifica	ation: Elective Compulsorv		
-		: Specialisation II. Mechatronics: Elective Comp	oulsory	
	Mechanical Engineering and Management:	Specialisation Mechatronics: Elective Compulso	ory	
	Mechatronics: Specialisation System Design	n: Elective Compulsory		
	Mechatronics: Specialisation Intelligent System	tems and Robotics: Elective Compulsory		
		icial Organs and Regenerative Medicine: Electi		
		lants and Endoprostheses: Elective Compulsory		
		ical Technology and Control Theory: Elective C		
		agement and Business Administration: Elective ction: Core Qualification: Elective Compulsory	compulsory	
	Theoretical Mechanical Engineering: Core Q			

urse L0702: Nonlinear Dynamics		
Тур	Integrated Lecture	
Hrs/wk	4	
CP	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Norbert Hoffmann	
Language	DE/EN	
Cycle	SoSe	
Content	Fundamentals of Nonlinear Dynamics	
	 One dimensional problems Linear Stability Local Bifurcations Synchronisation Two dimensional problems Limit Cycles Global Bifurcations Chaos Lorenz Equations Fractals and Strange Attractors Predictability and Horizons 	
Literature	Steven Strogatz: Nonlinear Dynamics and Chaos.	

	dded Systems					
Courses						
Title			٦	Гур	Hrs/wk	СР
Embedded Systems (L0805)			L	ecture	3	3
Embedded Systems (L2938)			F	Project-/problem-based Learning	1	1
Embedded Systems (L0806)	1		F	Recitation Section (small)	1	2
Module Responsible	Prof. Heiko Falk					
Admission Requirements	None					
Recommended Previous	Computer Engineerin	.g				
Knowledge						
Educational Objectives	After taking part succ	essfully, students ha	ve reached the following	learning results		
Professional Competence						
Knowledge	Embedded systems c	an be defined as info	ormation processing syst	ems embedded into enclosing	products. Thi	s course teaches
	foundations of such s	systems. In particular	r, it deals with an introd	uction into these systems (not	ions, common	characteristics)
				al automata, specification of	distributed sy	vstems, task grap
	specification of real-ti	ime applications, trai	nslations between differe	ent models).		
	Another part covers	the hardware of em	bedded systems: Sons	ors, A/D and D/A converters,	real-time cap	able communicat
				reconfigurable logic and actua		
	introduction into rea	l-time operating sys	tems, middleware and	real-time scheduling. Finally,	the implemen	tation of embed
	systems using hardw	/are/software co-desi	gn (hardware/software p	partitioning, high-level transfor	mations of sp	ecifications, ener
	efficient realizations,	compilers for embed	ded processors) is cover	ed.		
CI. //						
Skills	Skills After having attended the course, students shall be able to realize simple embedded systems. The students s					
	relevant parts of technological competences to use in order to obtain a functional embedded systems. In particular, they shall l able to compare different models of computations and feasible techniques for system-level design. They shall be able to judge					
	which areas of embed			chiliques for system-level des	ign. mey sna	ii be able to juug
Personal Competence		Jueu system design :	specific fisks exist.			
		solve similar problem	e alone or in a group an	d to present the results accord	inaly	
Joelar competence	Students are able to .	solve similar problem		a to present the results accord	iligiy.	
Autonomy	Students are able to a	acquire new knowled	ge from specific literatu	e and to associate this knowle	dge with othe	r classes.
Workload in Hours	Independent Study Ti	ime 110 Study Time	in Lecture 70			
Credit points		ine 110, Study fille	In Lecture 70			
Course achievement	Compulsory Bonus	Form	Description			
course acmevement	Yes 10 %	Subject theoretic				
		practical work				
Examination	Written exam					
Examination duration and	90 minutes, contents	of course and labs				
scale						
Assignment for the	General Engineering	Science (German pro	gram, 7 semester): Spec	ialisation Computer Science: C	Compulsory	
Following Curricula	Computer Science: S	pecialisation I. Comp	uter and Software Engine	eering: Elective Compulsory		
	Electrical Engineering	3: Core Qualification:	Elective Compulsory			
	Engineering Science:	Specialisation Mecha	atronics: Elective Compu	lsory		
	Engineering Science:	Specialisation Electr	ical Engineering: Elective	e Compulsory		
	Aircraft Systems Engi	ineering: Core Qualifi	cation: Elective Compuls	ory		
	General Engineering	Science (English prog	gram, 7 semester): Speci	alisation Mechatronics: Electiv	e Compulsory	
	Computer Science in	Engineering: Core Qu	ualification: Compulsory			
	Mechatronics: Specia	lisation System Desig	gn: Elective Compulsory			
	Mechatronics: Specia	lisation Intelligent Sy	stems and Robotics: Ele	ctive Compulsory		

Course L0805: Embedded Sy	stems		
Тур	Lecture		
Hrs/wk			
СР	3		
Workload in Hours	Independent Study Time 48, 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 L2938: Embedded Sy	stems		
Тур	Project-/problem-based Learning		
Hrs/wk	i.		
CP	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
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. 		

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

Courses				
Title		Тур	Hrs/wk	СР
Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics) (L0516)		Lecture	2	3
Technical Acoustics I (Acoustic Wav	es, Noise Protection, Psycho Acoustics) (L0518)	Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics)			
Knowledge	Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached t	the following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge in acoustics regarding acoustic waves, noise protection, and psycho acoustics ar			
	are able to give an overview of the corresponding the	pretical and methodical basis.		
Skille	The students are capable to bandle engineering	problems in accurtics by theory by	and application	of the domandi
	s The students are capable to handle engineering problems in acoustics by theory-based application of the demandin methodologies and measurement procedures treated within the module.			
	methodologies and measurement procedures dealed	within the module.		
Personal Competence				
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.			
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possibl			
Autonomy	conflicting issues and limitations can be identified and the results are critically scrutinized.			
		·····, -····, -····		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Energy Systems: Core Qualification: Elective Compulse	ory		
Following Curricula	Aircraft Systems Engineering: Core Qualification: Elect	ive Compulsory		
	International Management and Engineering: Specialisa	ation II. Aviation Systems: Elective Com	oulsory	
	Mechatronics: Specialisation System Design: Elective (
	Product Development, Materials and Production: Core			
	Technomathematics: Specialisation III. Engineering Sci			
	Theoretical Mechanical Engineering: Specialisation Pro	duct Dovelopment and Broduction, Elec	tive Compulsory	

Course L0516: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)		
Lecture		
Independent Study Time 62, Study Time in Lecture 28		
Prof. Benedikt Kriegesmann, DrIng. Sören Keuchel		
EN		
SoSe		
- 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		
Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin		
Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg		
Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg		

Course L0518: Technical Aco	urse L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)		
Тур	Recitation Section (large)		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Benedikt Kriegesmann, DrIng. Sören Keuchel		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses						
Title				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, M	Mechanics of Mate	rials) and Mechanics II ((Hydrostatics, Kinematics, Dyr	namics)	
Knowledge	Mathematics I, II, III (in	n particular differ	ential equations)			
Educational Objectives	After taking part succe	essfully students	have reached the follow	ving learning results		
Professional Competence	Filter taking part succe	costany, scadenes		ing learning results		
	The students possess	an in-denth know	wledge regarding the d	erivation of the boundary ele	ment method an	d are able to give
Kilomeage			lical basis of the method		ment method an	a are able to give
	overview of the theore					
Skills	The students are ca	apable to handle	e engineering problem	ns by formulating suitable	boundary eleme	nts, assembling
	corresponding system	n matrices, and so	lving the resulting syste	em of equations.		
Personal Competence						
	Students can work in a	small groups on s	pecific problems to arriv	ve at joint solutions		
Jocial competence	Students can work in a	sinan groups on s	pecific problems to arm	ve at joint solutions.		
Autonomy	The students are able	e to independentl	y solve challenging com	nputational problems and dev	elop own bound	ary element routin
	Problems can be ident	tified and the resu	ults are critically scrutini	ized.		
			,			
Workload in Hours	Independent Study Tin	me 124, Study Tir	ne in Lecture 56			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	No 20 %	Midterm				
Examination	Written exam					
Examination duration and	90 min					
scale						
Assignment for the	Civil Engineering: Spe-	cialisation Structu	ural Engineering: Electiv	e Compulsory		
-			chnical Engineering: Elec			
			I Engineering: Elective (
	Energy Systems: Core		5 5	· · · ·····		
				uct Development and Producti	on: Elective Com	aulcony
	-		esign: Elective Compulso	•	on. Liecuve Comp	Juisony
	mechatronics: Special	iisation System De	sign: Elective Compuis	ui y		
		-	-	tion floating C 1		
	Product Development,	, Materials and Pr	oduction: Core Qualifica	tion: Elective Compulsory		
	Product Development, Technomathematics: S	, Materials and Pr Specialisation III.	oduction: Core Qualifica Engineering Science: Ele	1 3		

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

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

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

	Τνρ		Hrs/wk	СР	
		e	3	4	
	Recitat	tion Section (large)	1	2	
Prof. Ralf God					
None					
Basic knowledge in:					
Mathematics					
Mechanics					
,					
Control Systems					
Previous knowledge in:					
• Aircraft Cabin Systems					
After taking part successfully students	have reached the following lear	ning results			
	in the redenied are relieving redi-	ing results			
Students are able to:					
• understand systems engineering proce	ess models, methods and tools f	or the development o	of complex System	าร	
 describe innovation processes and the 	e need for technology Managem	ent			
 explain the aircraft development proce 	ess and the process of type cert	ification for aircraft			
 explain the system development proce 	ess, including requirements for s	systems reliability			
 identify environmental conditions and 	test procedures for airborne Eq	uipment			
 value the methodology of requirement 	ts-based engineering (RBE) and	model-based requirer	ments engineering	រ (MBRE)	
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 	d technical Tasks				
 apply systems engineering methods a 	nd tools				
Students are able to:					
• understand and accept their tasks with	hin a development team				
• be comfortable with their role their tas	sks within the overall process				
 understand and serve their suppliers a 	and customers in large projects				
 assume responsibility for people and to 	echnology in the development o	of safety-critical syste	ms		
Students are able to:					
	pment team with division of tasl	ks.			
formulate requirements on their own					
 create test plans on their own and acc 	ompany certification processes				
Independent Study Time 124 Study Tim	ne in Lecture 56				
Aircraft Systems Engineering: Core Qual	lification: Compulsory				
		ystems: Elective Com	pulsory		
International Management and Engineer	ring: Specialisation II. Product D	evelopment and Produ	uction: Elective Co	ompulsory	
Mechatronics: Specialisation System De	sign: Elective Compulsory				
Mechatronics: Specialisation Intelligent 9	Systems and Robotics: Elective	Compulsory			
Product Development, Materials and Pro	duction: Specialisation Product	Development: Compu	llsory		
Product Development, Materials and Pro Product Development, Materials and Pro					
	None Basic knowledge in: Mathematics Mechanics Thermodynamics Electrical Engineering Control Systems Previous knowledge in: Aircraft Cabin Systems After taking part successfully, students i Students are able to: understand systems engineering processes and the explain the aircraft development processes and the explain the system development proces identify environmental conditions and value the methodology of requirement Students are able to: plan the process for the development organize the development phases and assign required business activities and apply systems engineering methods a Students are able to: understand and accept their tasks witt be comfortable with their role their task understand and serve their suppliers at assume responsibility for people and t Students are able to: interact and communicate in a develo independently research and identify c formulate requirements on their own create test plans on their own a	Prof. Ralf God None Basic knowledge in: • Mathematics • Mechanics • Mechanics • Thermodynamics • Electrical Engineering • Control Systems Previous knowledge in: • Aircraft Cabin Systems After taking part successfully, students have reached the following learn Students are able to: • understand systems engineering process models, methods and tools 1 • describe innovation processes and the need for technology Managem • explain the aircraft development process, including requirements for = • identify environmental conditions and test procedures for airborne Eq • value the methodology of requirements-based engineering (RBE) and Students are able to: • plan the process for the development of complex Systems • organize the development process, and technical Tasks • assign required business activities and technical Tasks • asplay systems engineering methods and tools Students are able to: • understand and accept their tasks within a development team • be comfortable with their role their tasks within the overall process • understand and accept their suppliers and customers in large projects • assume responsibility for people and technology in the development of Students are able to: • interact and communicate in a development team with division of task • independently research and identify certification specifications • iformulate requirements on their own • create test plans on their own and accompany certification processes Independent Study Time 124, Study Time in Lecture 56 6 None Written exam 120 Minutes Aircraft Systems Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Aviation S International Management and Engineering: Specialisation II. Aviation S Mechatronics: Specialisation Intelligent Systems and Robotics: Elective	Lecture Recitation Section (large) Prof. Ralf God None Basic knowledge in: • Mathematics • Mathematics • Mathematics • Mathematics • Thermodynamics • Iteratical Engineering • Control Systems • Previous knowledge in: • Arter taking part successfully, students have reached the following learning results Students are able to: • understand systems engineering process models, methods and tools for the development of • describe innovation processe and the need for technology Management • explain the aircraft development process, including requirements for systems reliability • identify environmental conditions and test procedures for aircore Equipment • value the methodology of requirements based engineering (RBE) and model-based requirer Students are able to: • plan the process for the development of complex Systems • organize the development process, including requirements for systems reliability • identify environmental conditions and test procedures for aircore Equipment • value the methodology of requirements-based engineering (RBE) and model-based requirer Students are able to: • plan the process for the development of complex Systems • organize the development phases and development Tasks • apply systems engineering methods and tools Students are able to: • understand and accept their tasks within the overall process • understand and accept their tasks within the overall process • understand and serve their suppliers and customers in large projects • assume responsibility for people and technology in the development of safety-critical systes Students are able to: • independently research and identify certification specification • independently research and identify certification specification • independently research and identify certification specification • induce requirements on their own • create test plans on their own and accompany certification functonal systems: Elective C	Leture 3 Recitation Section (large) 1 Prof. Ralf God None Basic knowledge in: Adhematics Mechanics Hermodynamics Electrical Engineering Electrical Engineering Electrical Engineering Electrical Engineering Control Systems Previous knowledge in: After taking part successfully, students have reached the following learning results Students are able to: understand systems engineering process models, methods and tools for the development of complex System esplain the aircraft development process and the process of type certification for aircraft explain the system development process and the process of type certification for aircraft explain the aircraft development process, including requirements for systems reliability identify environmental conditions and test procedures for airborne Equipment usule the methodology of requirements-based engineering (RBE) and model-based requirements engineering Students are able to: understand systems engineering methods and tools Students are able to: understand evelopment process and the process of type certification for aircraft explain the process for the development of complex Systems erganize the development process and the process of type certification for aircraft explain the process for the development of complex Systems i organize the development phases and development Tasks assign required business activities and technical Tasks apply systems engineering methods and tools Students are able to: understand and accept their tasks within a development to safety-critical systems students are able to: interact and communicate in a development team with division of tasks. independent team and their over effication specifications independent Study Time 124, Study Time in Lecture 56 6 None Written exam 120 Minutes Aircraft Systems Engineering: Specialisation II. Aivation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Aivation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Aivation Systems: E	

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

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

Courses				
Title		Тур	Hrs/wk	СР
Applied Automation (L1592)		Project-/problem-based Learning	3	3
Advanced Training Course SE-ZER	(L2739)	Project-/problem-based Learning	2	3
Development Management for Med	hatronics (L1512)	Lecture	2	3
atigue & Damage Tolerance (L03	0)	Lecture	2	3
ndustry 4.0 for engineers (L2012)		Lecture	2	3
Microcontroller Circuits: Implement	ation in Hardware and Software (L0087)	Seminar	2	2
Microsystems Technology (L0724)		Lecture	2	4
Model-Based Systems Engineering	(MBSE) with SysML/UML (L1551)	Project-/problem-based Learning	3	3
Sustainable Industrial Production (I	2863)	Lecture	2	4
Process Measurement Engineering		Lecture	2	3
Process Measurement Engineering		Recitation Section (large)	1	1
eedback Control in Medical Techn	blogy (L0664)	Lecture	2	3
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fo	llowing learning results		
Professional Competence				
Knowledge				
Kilowicage	 Students are able to express their extended knowled 	dge and discuss the connection of di	fferent specia	l fields or applica
	areas of mechatronics			
	Students are qualified to connect different special fields with each other			
SKIIIS	 Skills Students can apply specialized solution strategies and new scientific methods in selected areas 			
	 Students are able to transfer learned skills to new an 			approaches
Personal Competence				
-	No			
Social Competence	None			
Autonomy	 Students are able to develop their knowledge and ski 	ills by autonomous election of course	s.	
Workload in Hours	Depends on choice of courses			
Credit points				
-	Mechatronics: Specialisation System Design: Elective Comp	•		
	Mechatronics: Specialisation Intelligent Systems and Roboti	Flasting Communication		

Course L1592	2: Applied Automation
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in	Independent Study Time 48, Study Time in Lecture 42
Hours	
Examination	Mündliche Prüfung
Form	
Examination	30 Minuten
duration	
and scale	
	Prof. Thorsten Schüppstuhl
Language	
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 L2739: Advanced Tra	Course L2739: Advanced Training Course SE-ZERT				
Тур	Project-/problem-based Learning				
Hrs/wk					
CP	3				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Examination Form	Klausur				
Examination duration and	120 min				
scale					
Lecturer	Prof. Ralf God				
Language	DE				
Cycle	SoSe				
Content					
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der deutschen Übersetzung), ISBN 978-3-9818805-0-2.				
	ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System Life Cycle Processes).				

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

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

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

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

Course L0724: Microsystems	Technology
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	
	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) 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, roy process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origam imicrostructures, 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; cellerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, capanic semiconductor gas sensor, capanic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pri-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip)
	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

ανΤ	Project-/problem-based Learning
Hrs/wk	
CP	
	Independent Study Time 48, Study Time in Lecture 42
	Schriftliche Ausarbeitung
Examination duration and	
scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal languages
	SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Based
	Systems Engineering (MBSE) on a realistic hardware platform (e.g. Arduino®, Raspberry Pi®):
	What is a model?
	What is Systems Engineering?
	Survey of MBSE methodologies
	The modelling languages SysML /UML
	Tools for MBSE
	Best practices for MBSE
	Requirements specification, functional architecture, specification of a solution
	From model to software code
	Validation and verification: XiL methods
	Accompanying MBSE project
114	
Literature	- Skript zur Vorlesung
	- Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008
	- Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011

Тур	Lecture
Hrs/wk	
CP	4
-	4 Independent Study Time 92, Study Time in Lecture 28
ixamination duration and	
scale	
	Dr. Simon Markus Kothe
Language	
Cycle	
Content	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufactur processes that change the form and physical properties of raw materials. Manufacturing is a central driver of econo development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities resi in enormous global energy and material demands that are harmful to both the environment and people. Historically, indust activities were mostly oriented towards economic constraints, while social and environmental consequences were only ha considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the nat regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. Thi emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Ear annual regenerative capacity. This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cycle products. For this, the following topics will be highlighted: - Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance tomorrow's manufacturing; - raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for environmental impact of manufacturing; - Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy a resource efficiency;
	 Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps modeling (1), evaluating (2) and improving (3); Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA); Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product cycle assessment.
Literature	Literatur:
	- Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing.
	 Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Ch Springer International Publishing. Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapo Springer.
	 Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer Internatio Publishing. Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG.

Typ Lecture Hrs/wk 2 CP 3 Workload in Hours Independent Study Time 62, Study Time in Lecture 28 Examination form Mindliche Prüfung Examination duration and scale Simulation Lacturer Prof. Rolland Harig Language DEF/IN Content Process measurement engineering in the context of process control engineering Content Content Process measurement engineering Challenges of process measurement engineering Challenges of process measurement engineering Classification of pickups Systems theory in process measurement engineering Generic linear 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 Kencke, kronnüller: "Meßtechnik", Springer-Verlag Berlin Heidelberg, 1995 A. Ambardar: "Analog and Digital Signal Processing" (1), WWS Publishing Company, 1995, NTC 339 A. Papoullis: "Signal Analysis" (1), MicGraw-Hill, 1980, 2402095 S. Haykin: "Communication Systems" (1.3), Wiley&Sons, 1983, 2419072 H. Sheingold: "Analog-Digital Conversi	Course L1077: Process Meas	urement Engineering
CP 3 Workload in Hours Independent Study Time 62, Study Time in Lecture 28 Examination form Mindliche Prüfung Examination duration and scale 45 Minuten 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 Intermentation of process measurement engineering Instrumentation of process Classification of pickups Systems theory in process measurement engineering Generic linear description of tokups Systems theory in process measurement Wide band signals Auto- and cross-correlation function and their applications Fault-free operation of correlational measurement signals Modulation process (amplitude and frequency modulation) Multiplexing Analog to digital converter Literature Farber: _ProzeBrechentechnik*, Springer Verlag Berlin Heidelberg, 1995 -A. Ambardar: _Analog and Digital Signal Processing* (1), PWS Publishing Company, 1995, NTC 339 -A. Popoullis: _signal Analysis* (1), McGraw-Hill, 1980, 2402095 S. Haykin: _Communication Systems* (1,3), Wiley&Sons, 1983, 2419072	Тур	Lecture
Workload in Nouri Examination Form Mindliche Pröfung Examination duration and scale Languago DE/EN Cycle 505e Content • Process measurement engineering in the context of process control engineering • Challenges of process measurement engineering • Challenges of process measurement engineering • Challenges of process measurement engineering • Classification of pickups • Systems theory in process measurement engineering • Cassification of pickups • Systems theory in process measurement engineering • Classification of pickups • Systems theory in process measurement engineering • Content in ear 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: "ProzeErrechentechnik", Springer-Verlag 1994 - Kiencke, Kronmüller: "MeBtechnik", Springer-Verlag 1994 - Kiencke, Kronmüller: "MeBtechnik", Springer-Verlag Berlin Heldelberg, 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	Hrs/wk	2
Examination Form Mündliche Prüfung Examination duration and 45 Minuterin 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 and measurement signals • Modulation process (amplitude and frequency modulation) • Multiplexing • Analog to digital converter Literature • Färber: "ProzeBrechentechnik", Springer-Verlag 1994 • Kiencke, Kronmüller: "MeBtechnik", 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, 24	CP	3
Examination duration and scale 45 Minuten 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 • Generic linear description of pickups • Generic attained description of pickups • Ruthermatical description of pickups • 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 • Multiplexing • Analog to digital converter Literature • Färber: _Proze&rechentechnik", Springer-Verlag 1994 • Kiencke, Kromüller: _Me8technik", 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	Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
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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 pickups Mathematical description of pickups Mathematical 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 Multiplexing Analog to digital converter Literature Färber: "ProzeBrechentechnik", 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	Lecturer	Prof. Roland Harig
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 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 		Transmission of analog and digital measurement signals
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		- M. Schwartz: "Information Transmission, Modulation and Noise" (3,4), McGraw-Hill, 1980, 2402095
- H. Sheingold: "Analog-Digital Conversion Handbook" (5), Prentice-Hall, 1986, 2440072		- 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		- J. Fraden: "AIP Handbook of Modern Sensors" (5,6), American Institute of Physics, 1993, MTB 346

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

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

Courses			
Title	Тур	Hrs/wk	СР
Applied Automation (L1592)	Project-/problem-based Learning	3	3
Advanced Training Course SE-ZER	(L2739) Project-/problem-based Learning	2	3
Development Management for Med	hatronics (L1512) Lecture	2	3
atigue & Damage Tolerance (L03	0) Lecture	2	3
ndustry 4.0 for engineers (L2012)	Lecture	2	3
Microcontroller Circuits: Implement	ation in Hardware and Software (L0087) Seminar	2	2
Microsystems Technology (L0724)	Lecture	2	4
Model-Based Systems Engineering	(MBSE) with SysML/UML (L1551) Project-/problem-based Learning	3	3
Sustainable Industrial Production (I	2863) Lecture	2	4
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
Module Responsible	NN		
Admission Requirements	None		
Recommended Previous	None		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	Students are able to express their extended knowledge and discuss the connection of of	lifferent specia	I fields or applicat
Knowledge	 Students are able to express their extended knowledge and discuss the connection of or areas of mechatronics 	lifferent specia	I fields or applicat
Knowledge		lifferent specia	I fields or applicat
-	areas of mechatronics	lifferent specia	I fields or applicat
Knowledge Skills	areas of mechatronicsStudents are qualified to connect different special fields with each other		I fields or applicat
-	areas of mechatronics	l areas	
Skills	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected 	l areas	
Skills Personal Competence	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can devel 	l areas	
Skills Personal Competence Social Competence	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can devel 	l areas	
Skills Personal Competence	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can devel 	d areas op own solution	
Skills Personal Competence Social Competence Autonomy	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selecter Students are able to transfer learned skills to new and unknown problems and can devel None	d areas op own solution	
Skills Personal Competence Social Competence Autonomy	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selecter Students are able to transfer learned skills to new and unknown problems and can devel None Students are able to develop their knowledge and skills by autonomous election of course 	d areas op own solution	
Skills Personal Competence Social Competence Autonomy Workload in Hours Credit points	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selecter Students are able to transfer learned skills to new and unknown problems and can devel None Students are able to develop their knowledge and skills by autonomous election of course 	d areas op own solution	
Skills Personal Competence Social Competence Autonomy Workload in Hours Credit points Assignment for the	 areas of mechatronics Students are qualified to connect different special fields with each other Students can apply specialized solution strategies and new scientific methods in selected Students are able to transfer learned skills to new and unknown problems and can devel None Students are able to develop their knowledge and skills by autonomous election of course 6	d areas op own solution	

Course L1592	2: Applied Automation
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in	Independent Study Time 48, Study Time in Lecture 42
Hours	
Examination	Mündliche Prüfung
Form	
Examination	30 Minuten
duration	
and scale	
	Prof. Thorsten Schüppstuhl
Language	
Cycle Content	
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 L2739: Advanced Tra	ourse L2739: Advanced Training Course SE-ZERT	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	120 min	
scale		
Lecturer	Prof. Ralf God	
Language	DE	
Cycle	SoSe	
Content		
Literature	INCOSE Systems Engineering Handbuch - Ein Leitfaden für Systemlebenszyklus-Prozesse und -Aktivitäten, GfSE (Hrsg. der deutschen Übersetzung), ISBN 978-3-9818805-0-2.	
	ISO/IEC 15288 System- und Software-Engineering - System-Lebenszyklus-Prozesse (Systems and Software Engineering - System Life Cycle Processes).	

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

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

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

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

CP 4 Workload in Hours Ind	ndependent Study Time 92, Study Time in Lecture 28					
Workload in Hours Ind	ndependent Study Time 92, Study Time in Lecture 28					
Examination Form Mi						
EXamination Form	-					
Examination duration and 30	0 min					
scale						
Lecturer Pr	rof. Hoc Khiem Trieu					
Language EN	N					
Cycle W	liSe					
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, njunction, 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; angentoresistive sensors: segneting principle and fabrication process; Magnetic Sensors (galvanomagnetic sensors: splinning current Hall sensor and magneto-transistor; magnetoresistive sensor; organic semiconductor gas sensor, planetometer) Chemical and Bio Sensors (thermal gas sensors: planitor and thermal conductivity sensor; metal oxide semiconductor gas sensor, grain certiconductor gas sensor, alternal and FMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors); Lambdad pr					
Literature M.	I. Madou: Fundamentals of Microfabrication, CRC Press, 2002					
	. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009 . M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010					
	. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010 . Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008					

Тур	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Schriftliche Ausarbeitung
Examination duration and	ca. 10 Seiten
scale	
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal language
	SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Base
	Systems Engineering (MBSE) on a realistic hardware platform (e.g. Arduino®, Raspberry Pi®):
	What is a model?
	What is Systems Engineering?
	Survey of MBSE methodologies
	The modelling languages SysML /UML
	Tools for MBSE
	Best practices for MBSE
	Requirements specification, functional architecture, specification of a solution
	From model to software code
	Validation and verification: XiL methods
	Accompanying MBSE project
Literature	- Skript zur Vorlesung
Literature	- Skipt zur Vollesung - Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008
	- Weintens, T.: Systems Engineering mit Sysmi, one. Modellering, Analyse, Design. 2. Aurage, dpunkt. verag, 2008 - Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011
	- noit, J., reny, S.A., brownsword, M.: Model-based Requirements Engineering. Institution Engineering & Tech, 2011

Тур	Lecture
Hrs/wk	
CP	4
-	4 Independent Study Time 92, Study Time in Lecture 28
ixamination duration and	
scale	
	Dr. Simon Markus Kothe
Language	
Cycle	
Content	Industrial production deals with the manufacture of physical products to satisfy human needs using various manufactur processes that change the form and physical properties of raw materials. Manufacturing is a central driver of econo development and has a major impact on the well-being of humanity. However, the scale of current manufacturing activities resi in enormous global energy and material demands that are harmful to both the environment and people. Historically, indust activities were mostly oriented towards economic constraints, while social and environmental consequences were only ha considered. As a result, today's global consumption rates of many resources and associated emissions often exceed the nat regeneration rate of our planet. In this respect, current industrial production can mostly be described as unsustainable. Thi emphasized each year by the Earth Overshoot Day, which marks the day when humanity's ecological footprint exceeds the Ear annual regenerative capacity. This lecture aims to provide the motivation, analytical methods as well as approaches for sustainable industrial production and clarify the influence of the production phase in relation to the raw material, use and recycling phases in the entire life cycle products. For this, the following topics will be highlighted: - Motivation for sustainable production, the 17 Sustainable Development Goals (SDGs) of the UN and their relevance tomorrow's manufacturing; - raw material vs. production phase vs. use phase vs. recycling/end-of-life phase: importance of the production phase for environmental impact of manufacturing; - Typical energy- and resource-intensive processes in industrial production and innovative approaches to increase energy a resource efficiency;
	 Methodology for optimizing the energy and resource efficiency of industrial manufacturing chains with the three steps modeling (1), evaluating (2) and improving (3); Resource efficiency of industrial manufacturing value chains and its assessment using life cycle analysis (LCA); Exercise: LCA analysis of a manufacturing process (thermoplastic joining of an aircraft fuselage segment) as part of a product cycle assessment.
Literature	Literatur:
	- Stefan Alexander (2020): Resource efficiency in manufacturing value chains. Cham: Springer International Publishing.
	 Hauschild, Michael Z.; Rosenbaum, Ralph K.; Olsen, Stig Irving (Hg.) (2018): Life Cycle Assessment. Theory and Practice. Ch Springer International Publishing. Kishita, Yusuke; Matsumoto, Mitsutaka; Inoue, Masato; Fukushige, Shinichi (2021): EcoDesign and sustainability. Singapo Springer.
	 Schebek, Liselotte; Herrmann, Christoph; Cerdas, Felipe (2019): Progress in Life Cycle Assessment. Cham: Springer Internatio Publishing. Thiede, Sebastian; Hermann, Christoph (2019): Eco-factories of the future. Cham: Springer Nature Switzerland AG.

Course L1077: Process Meas	urement Engineering				
Тур	Lecture				
Hrs/wk	2				
CP	3				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Examination Form	indliche Prüfung				
Examination duration and	-				
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 				
	 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				
Encidatare					
	- 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 Meas	Course L1083: Process Measurement Engineering		
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Examination Form	Mündliche Prüfung		
Examination duration and			
scale			
Lecturer	Prof. Roland Harig		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

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

Courses					
F itle .ab Cyber-Physical Systems (L1740) Project-/problem-based Learning	Hrs/wk 4	CP 6		
Module Responsible	Prof. Heiko Falk				
Admission Requirements	None				
Recommended Previous	Module "Embedded Systems"				
Knowledge					
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	e Cyber-Physical Systems (CPS) are tightly integrated with their surrounding environment, via sensors, A/D and D/A converters, an 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 to lab introduces into the area (basic notions, characteristical properties) and their specification techniques (models of co- hierarchical automata, data flow models, petri nets, imperative approaches). Since CPS frequently perform control task experiments will base on simple control applications. The experiments will use state-of-the-art industrial specific (MATLAB/Simulink, LabVIEW, NXC) in order to model cyber-physical models that interact with the environment via se 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 converted 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 specificat 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 accordin	ngly.			
Autonomy	Students are able to acquire new knowledge from specific literature and to associate this knowledge	lge with other	classes.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written elaboration				
Examination duration and	Execution and documentation of all lab experiments				
scale					
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Computer Science: El	ective Compu	llsory		
Following Curricula	Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory				
	Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective (Compulsory			
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory				
	Mechatronics: Specialisation System Design: Elective Compulsory				

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

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

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

Course L1834: Control Lab V	11
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Herbert Werner, Patrick Göttsch
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

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

Courses				
Fitle	Тур)	Hrs/wk	СР
Advanced Topics in Vibration (L174	13) Proje	ect-/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 following lea	arning results		
Professional Competence				
Knowledge		1.00		
	Students are able to reflect existing terms and concepts of Advanced			
	 Students are able to identify the need to develop and research new t 	terms and concepts in vibration	15.	
Skills				
	Students are able to apply existing methods and procesures of Advan			
	 Students are able to develop novel methods and procedures for advantage 	anced vibration problems.		
Personal Competence				
Social Competence				
	Students can reach working results also in groups.			
	 Students can present working results also in groups. 			
Autonomy				
	Students are able to approach given research tasks individually			
	 Students are able to identify and follow up novel research tasks by the 	hemselves.		
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 Compulsory			
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Electiv	e Compulsory		
	Mechatronics: Technical Complementary Course: Elective Compulsory	/		
	Theoretical Mechanical Engineering: Specialisation Product Developm		Compulsory	
	Theoretical Mechanical Engineering: Specialisation Simulation Techno			
	Theoretical Mechanical Engineering: Specialisation Simulation Techno	ology: Elective Compulsory		

Course L1743: Advanced Top	ourse L1743: Advanced Topics in Vibration	
Тур	Project-/problem-based Learning	
Hrs/wk	4	
СР	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Norbert Hoffmann	
Language	DE/EN	
Cycle	SoSe	
	Advanced and Research Topics in Vibrations Rotor Dynamics Modal Analysis Model Order Reduction Stability of Periodic Solutions Random Vibrations	
Literature	Aktuelle Veröffentlichungen / Recent research publications Bücher/Books: Gasch, Nordmann, Pfützner: Rotordynamik Gasch, Knothe, Liebich: Strukturdynamik	

Module M0835: Huma				
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	5		
Educational Objectives	After taking part successfully, student	ts have reached the following learning results		
Professional Competence				
Knowledge	 Students can explain humanoid 	d robots		
		ontrol concepts for different tasks in humanoid ro	botics.	
Skills	 Students acquire knowledge at 	pout selected aspects of humanoid robotics, based	d on specified literature	
	Students generalize developed	results and present them to the participants		
	 Students practice to prepare an 	nd give a presentation		
Personal Competence				
Social Competence				
Social Competence	 Students are capable of development 	ping solutions in interdisciplinary teams and pres	ent them	
	 They are able to provide appro 	priate feedback and handle constructive criticism	of their own results	
Autonomy				
Autonomy	 Students evaluate advantages 	s and drawbacks of different forms of presenta	tion for specific tasks	and select the be
	solution			
		es with a scientific field, are able of introduce it	and follow presentation	ns of other studen
	such that a scientific discussion	n develops		
Workload in Hours	Independent Study Time 32, Study Ti	me in Lecture 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Mechatronics: Specialisation Intelliger	nt Systems and Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System I			
		n Artificial Organs and Regenerative Medicine: Ele		
		n Implants and Endoprostheses: Elective Compuls		
		n Medical Technology and Control Theory: Elective		
		n Management and Business Administration: Elect		
	I neoretical Mechanical Engineering: 5	Specialisation Robotics and Computer Science: Ele	ective Compulsory	

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

Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Ident	ification (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Classical control (frequency response)	inse, root locus)		
	State space methods			
	Discrete-time systems	e no na siti a n		
	Linear algebra, singular value dec			
	 Basic knowledge about stochastic 	processes		
Educational Objectives	After taking part successfully, students h	nave reached the following learning results		
Professional Competence				
Knowledge	Students can explain the general	I framework of the prediction error method	and its application to a	variaty of linear a
	nonlinear model structures	r hanework of the prediction error method	and its application to a	variety of fifiear a
		perceptron networks are used to model nonlin	ear dynamics	
		nate predictive control scheme can be based	-	lc
		pace identification and its relation to Kalman		.15
Skills	 Students are canable of applying 	g the predicition error method to the experi	mental identification of	linear and nonlin
	models for dynamic systems	g the prediction error method to the expen		
		a nonlinear predictive control scheme based	on a neural network mo	del
		space algorithms to the experimental identific		
		dard software tools (including the Matlab Syst		
Personal Competence				
Social Competence	Students can work in mixed groups on s	pecific problems to arrive at joint solutions.		
Autonomy	Students are able to find required inform	nation in sources provided (lecture notes, liter	rature, software docume	ntation) and use if
,	solve given problems.			,
	5			
	Independent Study Time 62, Study Time	in Lecture 28		
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Co	ntrol and Power Systems Engineering: Elective	e Compulsory	
Following Curricula		Systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Des			
		rtificial Organs and Regenerative Medicine: E		
		mplants and Endoprostheses: Elective Compu		
		ledical Technology and Control Theory: Comp		
		Ianagement and Business Administration: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Cor	e Qualification: Elective Compulsory		

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

Module M0939: Contro	ol Lab A			
Courses				
Title		Тур	Hrs/wk	СР
Control Lab I (L1093)		Practical Course	1	1
Control Lab II (L1291)		Practical Course	1	1
Control Lab III (L1665)		Practical Course	1	1
Control Lab IV (L1666)		Practical Course	1	1
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	State space methods			
Knowledge	•			
	LQG control			
	H2 and H-infinity optimal control	a a sky a l		
	 uncertain plant models and robust c LPV control 	Control		
	LPV control			
Educational Objectives	After taking part successfully, students have	ve reached the following learning results		
Professional Competence				
Knowledge	Students can explain the difference	between validation of a control lop in simulation	on and experimental v	validation
Skills	 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LC 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 LPV gain-scheduled controllers 			
Personal Competence				
Social Competence				
	 Students can work in teams to cond 	luct experiments and document the results		
Autonomy	Students can independently carry o	ut simulation studies to design and validate co	ntrol loops	
Workload in Hours	Independent Study Time 64, Study Time in	Lecture 56		
Credit points	4			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	1			
scale				
		rol and Power Systems Engineering: Elective Co	ompulsory	
Following Curricula	Mechatronics: Specialisation System Desig			
	Mechatronics: Specialisation Intelligent Sys			
		alisation Robotics and Computer Science: Elect	to a construction of a second	

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

Module Manual M.Sc. "Mechatronics"

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

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

Course L1666: Control Lab IV	1		
Тур	Practical Course		
Hrs/wk	1		
CP	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	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 Renne	r			
Admission Requirements	None				
Recommended Previous					
Knowledge	, ,		e in programming in the C language		
	Basic knowledge in s				
	 Basic understanding 	of assembly language			
Educational Objectives	After taking part successful	ly, students have reache	d the following learning results		
Professional Competence					
Knowledge	Students know the basic pr	inciples and procedures	of software engineering for embedded s	ystems. They are	able to describe the
	usage and pros of event	based programming u	sing interrupts. They know the comp	onents and fund	tions of a concre
	microcontroller. The partici	pants explain requireme	nts of real time systems. They know at	least three sche	duling algorithms f
	real time operating systems	s including their pros and	cons.		
Skills	Students build interrupt-ba	sed programs for a con	crete microcontroller. They build and us	se a preemptive	scheduler. They us
	peripheral components (timer, ADC, EEPROM) to realize complex tasks for embedded systems. To interface with exte				
	components they utilize ser	ial protocols.			
Personal Competence					
Social Competence					
Autonomy					
Workload in Hours	Independent Study Time 11	.0, Study Time in Lecture	70		
Credit points	6				
Course achievement	Compulsory Bonus Form		Description		
	No 10 % Atte	station			
Examination	Written exam				
Examination duration and	90 min				
scale					
Assignment for the	Computer Science: Speciali	sation I. Computer and S	oftware Engineering: Elective Compulsor	4	
Following Curricula	Electrical Engineering: Spec	ialisation Information an	d Communication Systems: Elective Com	pulsory	
	Information and Communic	ation Systems: Specialisa	tion Communication Systems, Focus Soft	ware: Elective Co	ompulsory
	Mechatronics: Technical Co	mplementary Course: Ele	ctive Compulsory		
	Mechatronics: Specialisatio	n Intelligent Systems and	Robotics: Elective Compulsory		
	Mechatronics: Specialisatio	n System Design: Elective	e Compulsory		
	Microelectronics and Micros	watering Enocialization E	abaddad Custanas, Elastina Commulas,		

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

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

Courses				
Title		Тур	Hrs/wk	СР
Compilers for Embedded Systems ((L1692)	Lecture	3	4
Compilers for Embedded Systems ((L1693)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Heiko Falk			
Admission Requirements	None			
Recommended Previous	Module "Embedded Systems"			
Knowledge	C/C++ Programming skills			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Nonege	embedded processors grows continuously du of embedded systems, highly optimized an impose high demands on compilers which has the students are able • to illustrate the structure and organiza • to distinguish and explain intermediate • to assess optimizations and their unde The high demands on compilers for embed particular, • which kinds of optimizations are applie • how the translation from source code t • which kinds of optimizations are applie • how register allocation is performed, a • how memory hierarchies can be exploit	e representations of various abstraction levels, and rlying problems in all compiler phases. Ided systems make effective code optimizations cable at the source code level, to assembly code is performed, cable at the assembly code level, ind	of the particu uch highly sp ccessful attend mandatory. Th	lar application are ecialized processo dance of this cours ne students learn
		nave to optimize for multiple objectives (e.g., aver earn to evaluate the influence of optimizations on t		
Skills	After successful completion of the course, students shall be able to translate high-level program code into machine code. They be enabled to assess which kind of code optimization should be applied most effectively at which abstraction level (e.g., source assembly code) within a compiler. While attending the labs, the students will learn to implement a fully functional compiler including optimizations.			
Personal Competence				
	Students are able to solve similar problems a	lone or in a group and to present the results accord	lingly.	
		from specific literature and to associate this knowle		r classes.
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points				
Course achievement				
Examination				
Examination duration and				
scale				
Assignment for the	Computer Science: Specialisation I. Compute	r and Software Engineering: Elective Compulsory		
Following Curricula		tion and Communication Systems: Elective Compul	sory	
-	Aircraft Systems Engineering: Core Qualificat			
	Mechatronics: Specialisation Intelligent Syste	ms and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design:	Elective Compulsory		
	Mechatronics: Technical Complementary Cou	rse: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialis	sation Robotics and Computer Science: Elective Cor	npulsory	

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

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

Courses						
Courses						
Title		Тур	Hrs/wk	СР		
Optimal and Robust Control (L0658 Optimal and Robust Control (L0659		Lecture Recitation Section (small)	2	3 3		
Module Responsible			-	5		
-						
Admission Requirements Recommended Previous	None					
Knowledge	Classical control (frequency response, root locus)					
Kilomeuge	State space methods					
	Linear algebra, singular value decomposition					
Educational Objectives	After taking part successfully, students have reached the	following learning results				
Professional Competence	Arter taking part successibility, statents have reached the					
Knowledge						
Knownedge	 Students can explain the significance of the matrix 	Riccati equation for the solution of	LQ problems.			
	 They can explain the duality between optimal state 	e feedback and optimal state estima	tion.			
	• They can explain how the H2 and H-infinity norms					
	They can explain how an LQG design problem can					
	They can explain how model uncertainty can be really as a base of the small sain blue based on the					
	 They can explain how - based on the small gain the an uncertain plant. 	leorem - a robust controller can gu	aranitee stability	and performance		
	 They understand how analysis and synthesis condi 	tions on feedback loops can be repr	esented as linear	matrix inequalitie		
				much mequande		
Skills	 Students are canable of designing and tuning LOG 	controllers for multivariable plant m	odels			
	 Students are capable of designing and tuning LQG controllers for multivariable plant models. They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standard 					
	software tools for solving it.	design problem in the form of d get	nerunzeu plune, u	ind of dailing stand		
	 They are capable of translating time and frequence 	cy domain specifications for control	loops into const	raints on closed-le		
	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-objectiv					
	robust controller.					
	 They are capable of formulating analysis and synt 	hesis conditions as linear matrix ine	qualities (LMI), a	nd of using standa		
	LMI-solvers for solving them.					
	They can carry out all of the above using standard	software tools (Matlab robust contro	ol toolbox).			
Personal Competence						
	Students can work in small groups on specific problems to	arrive at joint solutions				
	Students are able to find required information in sources	-	oftware docume	ntation) and use it		
Autonomy	solve given problems.			indución, una use n		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56					
Credit points						
Course achievement						
Examination						
Examination duration and						
scale						
-	Electrical Engineering: Specialisation Control and Power S	ystems Engineering: Elective Comp	ulsory			
Following Curricula	Energy Systems: Core Qualification: Elective Compulsory	Compulson				
	Aircraft Systems Engineering: Core Qualification: Elective					
	Mechatronics: Specialisation Intelligent Systems and Robe Mechatronics: Specialisation System Design: Elective Con					
	Biomedical Engineering: Specialisation Artificial Organs a		Compulsory			
	Biomedical Engineering: Specialisation Implants and Endo	-	compuisory			
	Biomedical Engineering: Specialisation Medical Technolog		pulsory			
	Biomedical Engineering: Specialisation Medical rectinoiog					
	Product Development, Materials and Production: Specialis					
	Product Development, Materials and Production: Specialis					
	Product Development, Materials and Production: Specialis	ation Materials: Elective Compulsor	4			
	Theoretical Mechanical Engineering: Core Qualification: E	ective Compulsory				

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

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

Module M1400: Desig							
Courses							
Title			Тур		Hrs/wk	СР	
Designing Dependable Systems (L2	2000)		Lecture	1	2	3	
Designing Dependable Systems (L2	2001)		Recitat	ion Section (small)	2	3	
Module Responsible	Prof. Görschwin Fey						
Admission Requirements	None						
Recommended Previous	Basic knowledge about	data structures and alg	orithms				
Knowledge							
Educational Objectives	After taking part succes	sfully, students have re	eached the following learn	ing results			
Professional Competence							
Knowledge	In the following "depend	dable" summarizes the	concepts Reliability, Avai	ability, Maintainabilit	y, Safety and Sec	urity.	
	Knowledge about approv	aches for designing de	andable systems e a				
	Kilowieuge about applo	acties for designing de	Sendable Systems, e.g.,				
	Structural solutio	ns like modular redund	ancy				
	Algorithmic soluti	ions like handling byza	ntine faults or checkpoint	ng			
	Knowledge about metho	ods for the analysis of c	lependable systems				
	internedge about metho		opendable bystems				
Skills	Ability to implement der	pendable systems using	the above approaches.				
		Ability to implement dependable systems using the above approaches.					
	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 t 						
	 present their solu 	itions orally.					
Autonomy	Using accompanying m	naterial students indep	endently learn in-depth	relations between co	oncepts explained	d in the lecture a	
	additional solution strate	egies.					
Workload in Hours	Independent Study Time	e 124, Study Time in Le	ecture 56				
Credit points	6						
Course achievement	Compulsory Bonus F	Form	Description				
	Yes None S	Subject theoretical	andDie Lösung einer Au	ıfgabe ist Zuslassung	gsvoraussetzung	für die Prüfung. D	
	7	practical work	Aufgabe wird in Vorle	esung und Übung def	iniert.		
Examination	Oral exam						
Examination duration and	30 min						
scale							
Assignment for the	Computer Science: Spec	cialisation I. Computer	and Software Engineering	Elective Compulsory	/		
Following Curricula	Computer Science in En	gineering: Specialisatio	on I. Computer Science: El	ective Compulsory			
	Information and Commu	unication Systems: Spe	cialisation Secure and Dep	pendable IT Systems:	Elective Compuls	sory	
	Mechatronics: Specialisa	ation System Design: E	lective Compulsory				
	Microelectronics and Mic	crosystems: Specialisat	ion Embedded Systems: I	Elective Compulsory			

Course L2000: Designing Dep	pendable Systems
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Görschwin Fey
Language	DE/EN
Cycle	SoSe
Content	Description
	The term dependability comprises various aspects of a system. These are typically:
	 Reliability Availability Maintainability
	MaintainabilitySafetySecurity
	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	

Course L2001: Designing Dependable Systems			
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	ndent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Görschwin Fey		
Language	EN		
Cycle	Se		
Content	e interlocking course		
Literature	See interlocking course		

Courses					
Title		Тур	Hrs/wk	СР	
Applied Design Methodology in Me	hatronics (11523)	Lecture	2	2	
Applied Design Methodology in Me		Project-/problem-based Learning	3	4	
Module Responsible	Prof. Thorsten Kern				
Admission Requirements					
	Basics of mechanical design, electrical design	gn or computer-sciences			
Knowledge					
Educational Objectives	After taking part successfully, students have	e reached the following learning results			
Professional Competence					
Knowledge	Science-based working on interdisciplinary	product design considering targeted application of sp	ecific product	design technique	
Skills	- ·	entific preparation and formulation of complex produ	ict design prot	olems / Applicatio	
	various product design techniques following	theoretical aspects.			
Personal Competence					
Social Competence	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application				
	common, creative methodologies.				
Autonomy	y Students are enabled to optimize the design and development process according to the target and topic of the desi				
	Chudanka are advanted to anarata in a development toom				
	Students are educated to operate in a deve	lopment team			
	Students learn about the right application o	f creative methods in engineering.			
Workload in Hours	Independent Study Time 110, Study Time in	Locture 70			
Credit points	Independent Study Time 110, Study Time in				
Course achievement					
Examination	Subject theoretical and practical work				
	30 min Presentation for a group design-work				
scale	So min Presentation for a group design-wor				
	International Management and Engineering	Specialisation II Product Development and Product	ion: Elective C	ompulsory	
-	 International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulso International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory 				
	Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory				
	Mechatronics: Specialisation System Design			,	
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
		ants and Endoprostheses: Elective Compulsory			
		ical Technology and Control Theory: Elective Compul	sory		
		agement and Business Administration: Elective Com	-		
	Theoretical Mechanical Engineering: Specia		-		

Тур	Lecture				
Hrs/wk	2				
CP					
Workload in Hours	ependent Study Time 32, Study Time in Lecture 28				
Lecturer	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, pl principles, elements for solution, combination to systems and products, execution of design, component-tests, system product-testing and qualification/validation) Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applicatie examples all around mechatronics topics) Several design-supporting methods and tools (functional structures, GALFMOS, AEIOU-method, GAMPFT, simulation a application, TRIZ, design for SixSigma, continous integration and testing,) Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-compar dealing with uncertainties, decision-making Value-analysis Derivation of architectures and architectural management Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&D departments identification, responsibilities and communication) Presentation-skills Questions of a selectic product design and design for subjective requirements (industrial design, color, haptic/optic/acounterfaces) Evaluation of selected methods at practical examples in small teams 				
Literature	Definition folgt Definition folgt				
	 Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Met und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 VDI-Richtlinien: 2206; 2221ff 				

Course L1524: Applied Desig	urse L1524: Applied Design Methodology in Mechatronics		
Тур	Project-/problem-based Learning		
Hrs/wk	3		
CP			
Workload in Hours	ependent Study Time 78, Study Time in Lecture 42		
Lecturer	f. Thorsten Kern		
Language			
Cycle	Se		
Content	e interlocking course		
Literature	interlocking course		

Courses						
		T	Hara ta da	65		
Title	nas, and Electromagnetic Compatibility (L1669)	Typ Lecture	Hrs/wk 3	CP 4		
	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2		
	Prof. Christian Schuster		_			
Admission Requirements	None					
Recommended Previous						
Kecommended Previous Knowledge	Basic principles of physics and electrical engineering					
-	After taking part successfully, students have reached to	a fallowing loopning regults				
	After taking part successfully, students have reached t	le following learning results				
Professional Competence						
Knowledge	Students can explain the basic principles, relationship	is, and methods for the design of wa	veguides and an	tennas as well as		
	Electromagnetic Compatibility. Specific topics are:					
	- Fundamental properties and phenomena of electrical	circuits				
	- Steady-state sinusoidal analysis of electrical circuits					
	- Fundamental properties and phenomena of electroma	gnetic 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					
Chille	Chudonka know have to apply verified mathematic and me	dele fer characterization and chaics at		antonnos Thous		
SKIIIS	Students know how to apply various methods and models for characterization and choice of waveguides and antennas. They are able to access and gualify their basic electromagnetic properties. They can apply results and strategies from the field of					
	able to assess and qualify their basic electromagnetic properties. They can apply results and strategies from the field of Electromagnetic Compatibility to the development of electrical components and systems.					
	Electromagnetic Compatibility to the development of el	ectrical components and systems.				
Personal Competence						
Social Competence	Students are able to work together on subject related	tasks in small groups. They are able	to present their	results effectively		
	English (e.g. during small group exercises).			-		
Autonomy	Students are capable to gather information from sul					
	context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of					
	other lectures (e.g. theory of electromagnetic fields, fu	indamentals of electrical engineering	/ physics). They c	an discuss technio		
	problems and physical effects in English.					
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70					
Credit points						
Course achievement	None					
Examination	Oral exam					
Examination duration and	45 min					
scale						
Assignment for the	General Engineering Science (German program, 7 sem	ester): Specialisation Electrical Engine	ering: Elective Co	mpulsory		
Following Curricula	Electrical Engineering: Core Qualification: Elective Com	pulsory				
	Engineering Science: Specialisation Electrical Engineer	ng: Elective Compulsory				
	Aircraft Systems Engineering: Core Qualification: Electi	ve Compulsory				
	Mechatronics: Specialisation System Design: Elective C					

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

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

Courses				
Title		Тур	Hrs/wk	СР
Machine Learning and Data Mining	(L0340)	Lecture	2	4
Machine Learning and Data Mining	(L0510)	Recitation Section (small)	2	2
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous Knowledge	Calculus			
	Stochastics			
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
Skills	can be improved by ensemble learning, and they can summarize how this influences computational learning theory. Algorith 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 na explain basic optimization techniques. They present and apply the basic idea of first-order inductive leaning. Students ap BME, MAP, ML, and EM algorithms for learning parameters of Bayesian networks and compare the different algorithms. The know how to carry out Gaussian mixture learning. They can contrast kNN classifiers, neural networks, and support machines, and name their basic application areas and algorithmic properties. Students can describe basic clustering tec- and explain the basic components of those techniques. Students compare related machine learning techniques, e.g., k clustering and nearest neighbor classification. They can distinguish various ensemble learning techniques and comp different goals of those techniques.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study Time	n Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
-	Computer Science: Specialisation II: Intellig			
Following Curricula		g: Specialisation II. Information Technology: Elec	tive Compulsory	
	Mechatronics: Technical Complementary C Mechatronics: Specialisation System Desig	1 3		
	Mechatronics: Technical Complementary C Mechatronics: Specialisation System Desig Mechatronics: Specialisation Intelligent Sys	n: Elective Compulsory		

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

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

Courses						
Title				Turn	Hrs/wk	СР
Flight Control Law Design and Application (L2448)				Typ Lecture	2	4
Flight Control Law Design and Appl				Project-/problem-based Learning		2
Module Responsible	Prof. Frank Thielecke					
Admission Requirements	None					
Recommended Previous	Basic knowledge in:					
Knowledge	* mathematics (linear	algebra and ordinary	y differential equations	;)		
	* control systems (trai	nsfer functions and s	tate space representat	tion)		
	* mechanics (rigid-boo	dy kinetics)				
	* flight mechanics					
Educational Objectives	After taking part succe	essfully, students hav	ve reached the followin	ng learning results		
Professional Competence						
Knowledge	Students are able to:					
	* describe and unders	tand flight dynamics	models for control tas	ks		
	* assess handling qualities and understand the need for augmentation through control systems					
	* identify fundamental performance limitations of control laws					
Skills	Students are able to:					
	* design model-based control laws for stability augmentation					
	* design model-based flight control laws					
	* assess robustness a	* assess robustness and performance of control laws				
Personal Competence						
Social Competence	Students are able to:					
	* design control laws in groups as well as discuss the requirements and results					
Autonomy	Students are able to:					
	* reflect on the contents of lectures and extend their knowledge through literature research					
	* solve control design	tasks with software t	tools			
Workload in Hours	Independent Study Tir	Independent Study Time 124, Study Time in Lecture 56				
Credit points						
Course achievement	Compulsory Bonus Form Description Yes None Attestation Die in der Vorlesung vermittelten Kenntnisse werden in ein semesterbegleitenden Projekt direkt auf das Modell eines Passagierflugze angewendet.					
Examination	Written exam					
Examination duration and scale	60 min					
	Aircraft Systems Engir	neering: Core Qualific	cation: Elective Compu	lsory		
Following Curricula			n: Elective Compulsory			
	Mechatronics: Technical Complementary Course: Elective Compulsory					
	Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory					

Course L2448: Flight Control	Law Design and Application
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Frank Thielecke, Dr. Julian Theis
Language	EN
Cycle	SoSe
	 * flight dynamics (equations of motion, trim and linearization, linear models of longitudinal and lateral-directional motion, eigenforms) * stability augmentation (modal dynamics, damper design with root-loci, pole placement and eigenstructure assignment) * primary flight control laws and autopilots * design of flight control laws (loopshaping design, robustness criteria and analysis, cascaded control loops, gain-scheduling) * verification of flight control laws in simulation
Literature	J. Theis: Lecture Notes Flight Control Law Design D. Schmidt: Modern Flight Dynamics B. Stevens, F. Lewis: Aircraft Control and Simulation D. McGruer, D. Graham, I. Ashkenas: Aircraft Dynamics and Automatic Control SAE Aerospace Standard 94900 - Flight Control Systems The MathWorks: Control Systems Design Toolbox User Guide

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

Courses					
Title		т	ур	Hrs/wk	СР
Lab Applied Dynamics (L1631)		Р	ractical Course	2	2
Applied Dynamics (L1630)		L	ecture	4	4
Module Responsible	Prof. Robert Seifried				
Admission Requirements	None				
Recommended Previous	Mathematics I, II, III, Mechanics I, II, II	I, IV			
Knowledge	Numerical Treatment of Ordinary Diff	erential Equations			
Educational Objectives	After taking part successfully, studen	ts have reached the following	learning results		
Professional Competence					
Knowledge	Students can represent the most important methods of dynamics after successful completion of the module Technical dynamic and have a good understanding of the main concepts in the technical dynamics.				
Skills	Students are able				
	+ to think holistically				
	+ to independently, securly and crit systems	ically analyze and optimize I	pasic problems of the	e dynamics of rigid ar	nd flexible multibo
	+ to describe dynamics problems ma	thematically			
	+ to investigate dynamics problems b	ooth experimentally and nume	erically		
Personal Competence					
Social Competence	Students are able to				
	+ solve problems in heterogeneous g	roups and to document the co	orresponding results.		
Autonomy	Students are able to				
	+ assess their knowledge by means o	f exercises and experiments.			
	+ acquaint themselves with the nece	ssary knowledge to solve rese	earch oriented tasks.		
Workload in Hours	Independent Study Time 96, Study Ti	me in Lecture 84			
Credit points	6				
Course achievement	Compulsory Bonus Form Yes None Subject the practical work	Description pretical and Versuche Fachle	abor		
Examination	Written exam				
Examination duration and	90 min				
scale					
Assignment for the	Mechatronics: Specialisation Intelliger	nt Systems and Robotics: Elec	tive Compulsory		
Following Curricula	Mechatronics: Specialisation System I	Design: Elective Compulsory			
	Theoretical Mechanical Engineering: (Core Qualification: Compulsor	v		

Course L1631: Lab Applied Dynamics		
Тур	Practical Course	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Dr. Marc-André Pick	
Language	DE	
Cycle	SoSe	
Content	Practical exercises are performed in groups. The examples are taken from different areas of applied dynamics, such as numerical simulation, experimental validation and experimental vibration analysis.	
Literature	Schiehlen, W.; Eberhard, P.: Technische Dynamik, 4. Auflage, Vieweg+Teubner: Wiesbaden, 2014.	

Course L1630: Applied Dynamics		
Тур	Lecture	
Hrs/wk	4	
CP	4	
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56	
Lecturer	Prof. Robert Seifried, Dr. Marc-André Pick	
Language	DE	
Cycle	SoSe	
Content	 Modelling of Multibody Systems Basics from kinematics and kinetics Constraints Multibody systems in minimal coordinates State space, linearization and modal analysis Multibody systems with kinematic constraints Multibody systems as DAE Non-holonomic multibody systems Experimental Methods in Dynamics 	
Literature	Schiehlen, W.; Eberhard, P.: Technische Dynamik, 4. Auflage, Vieweg+Teubner: Wiesbaden, 2014. Woernle, C.: Mehrkörpersysteme, Springer: Heidelberg, 2011. Seifried, R.: Dynamics of Underactuated Multibody Systems, Springer, 2014.	

Module M1173: Appli	ed Statistics			
Courses				
Title	Тур		Hrs/wk	СР
Applied Statistics (L1584)	Lectu	re	2	3
Applied Statistics (L1586)	Project	ct-/problem-based Learning	2	2
Applied Statistics (L1585)	Recita	ation Section (small)	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of statistical methods			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following lear	rning 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	None			
Examination	Written exam			
Examination duration and				
scale				
Assignment for the	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory			
Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Design: Elective Compulsory			
	Mechatronics: Core Qualification: Elective Compulsory			
	Biomedical Engineering: Core Qualification: Compulsory			
	Product Development, Materials and Production: Core Qualification: Ele	ective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Te	chnology: Elective Compul	sory	

Course L1584: Applied Statistics		
Тур	Lecture	
Hrs/wk	2	
CP	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	Course L1586: Applied Statistics		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Michael Morlock		
Language	DE/EN		
Cycle	WiSe		
Content	The students receive a problem task, which they have to solve in small groups (n=5). They do have to collect their own data and work with them. The results have to be presented in an executive summary at the end of the course.		
Literature	Selbst zu finden		

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

Courses				
Title		Тур	Hrs/wk	СР
	and Control of Autonomous Vehicles (L2869)	Integrated Lecture	1	1
	n into Mobile Underwater Robotics (L1981)	Project-/problem-based Learning	4	5
Module Responsible				
Admission Requirements	None			
Recommended Previous	Mechanics IV, Applied Dynamics or Robotics			
Knowledge	Numerical Treatment of Ordinary Differential Equation	ons		
	Control Systems Theory and Design			
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
Knowledge	After successful completion of the module studen areas of multibody dynamics and robotics	ts demonstrate deeper knowledge and und	erstanding in	selected applicati
Skills	Students are able			
	+ to think holistically			
	+ to independently, securly and critically analyze systems	and optimize basic problems of the dynam	ics of rigid a	nd flexible multibo
	+ to describe dynamics problems mathematically			
	+ to implement dynamical problems on hardware			
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous groups and to c	locument the corresponding results and prese	ent them	
Autonomy	Students are able to			
	+ assess their knowledge by means of exercises an	d projects.		
	+ acquaint themselves with the necessary knowled	ge to solve research oriented tasks.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture	e 70		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	ТВА			
scale				
-	Mechatronics: Specialisation Intelligent Systems and			
Following Curricula	Mechatronics: Specialisation System Design: Electiv			
	Mechatronics: Core Qualification: Elective Compulso Theoretical Mechanical Engineering: Core Qualificat	•		

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

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

Module M0652: AuVa	nced Topics in Control
Courses	
Title	Typ Hrs/wk CP
Advanced Topics in Control (L0661) Lecture 2 3
Advanced Topics in Control (L0662	Recitation Section (small) 2 3
Module Responsible	NN
Admission Requirements	None
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities
Knowledge	
Educational Objectives	
Professional Competence	
Knowledge	 Students can explain the advantages and shortcomings of the classical gain scheduling approach They can explain the representation of nonlinear systems in the form of quasi-LPV systems They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniqu associated with each of these model structures Students can explain how graph theoretic concepts are used to represent the communication topology of multiage systems They can explain the convergence properties of first order consensus protocols They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models Students can explain concepts behind linear and qLPV Model Predictive Control (MPC)
Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results.
	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	
Examination	
Examination duration and scale	
-	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory
Following Curricula	
	Aeronautics: Core Qualification: Elective Compulsory
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory
	Mechatronics: Specialisation System Design: Elective Compulsory
	Mechatronics: Core Qualification: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

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

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

Module M1598: Image	Processing			
Courses				
Title		Тур	Hrs/wk	СР
Image Processing (L2443)		Lecture	2	4
Image Processing (L2444)		Recitation Section (small)	2	2
Module Responsible	Prof. Tobias Knopp			
Admission Requirements	None			
Recommended Previous	Signal and Systems			
Knowledge				
Educational Objectives	After taking part successfully, students have rea	ached the following learning results		
Professional Competence				
Knowledge	The students know about			
	- visual perception			
	visual perception multidimensional signal processing			
	multidimensional signal processingsampling and sampling theorem			
	filtering			
	image enhancement			
	edge detection			
	 multi-resolution procedures: Gauss and L 	aplace pyramid, wavelets		
	image compression			
	image segmentation			
	 morphological image processing 			
Skille	The students can			
SKIIIS				
	 analyze, process, and improve multidime 	nsional image data		
	 implement simple compression algorithm 	IS		
	 design custom filters for specific applicat 	ions		
Personal Competence				
	Students can work on complex problems both in	dependently and in teams. They can exchan	nge ideas with eac	h other and use th
	individual strengths to solve the problem.			
	······			
Autonomy	Students are able to independently investigate	a complex problem and assess which compe	etencies are require	ed to solve it.
Workload in Hours	Independent Study Time 124, Study Time in Lea	ture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Data Science: Core Qualification: Elective Comp	ulsory		
Following Curricula	Data Science: Specialisation I. Mathematics/Cor	nputer Science: Elective Compulsory		
	Data Science: Specialisation II. Computer Science	ce: Elective Compulsory		
	Data Science: Specialisation IV. Special Focus A	rea: Elective Compulsory		
	Electrical Engineering: Specialisation Informatio	•	mpulsory	
	Electrical Engineering: Specialisation Medical Te			
	Information and Communication Systems: S	pecialisation Secure and Dependable IT	Systems, Focus S	oftware and Sig
	Processing: Elective Compulsory			
	Information and Communication Systems: Spec			ective Compulsory
	International Management and Engineering: Sp		ve Compulsory	
	Mechatronics: Specialisation Intelligent Systems			
	Mechatronics: Specialisation System Design: Ele			
	Mechatronics: Core Qualification: Elective Comp	•	octivo Compulsora	
	Microelectronics and Microsystems: Specialisati			
	Theoretical Mechanical Engineering: Specialisat	ion nobolics and computer science: Elective	compuisory	

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

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

Courses				
		Tree	Une hole	CP.
Title Integrated Circuit Design (L0691)		Typ Lecture	Hrs/wk 3	CP 4
ntegrated Circuit Design (L0998)		Recitation Section (small)	1	2
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous	Basic knowledge of (solid-state) physics and ma	thematics.		
Knowledge	Knowledge in fundamentals of electrical enginee	ring and electrical networks		
	Kilowiedge in fundamentals of electrical enginee			
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge	Students can explain basis conse	pts of electron transport in semico	nductor dovicos	s (energy ban
	-	trations, drift and diffusion current densities,		
		inciples of pn-diodes, MOS capacitors, and M	-	
	 Students can present and discuss current 	-voltage relationships and small-signal equive	alent circuits of th	ese devices.
	 Students can explain the physics and curr 	ent-voltage behavior transistors based on ch	arged carrier flow	
	 Students are able to explain the basic cor 	cepts for static and dynamic logic gates for i	ntegrated circuits	
	 Students can exemplify approaches for lo 	w power consumption on the device and circ	uit level	
	 Students can describe the potential and li 	mitations of analytical expression for device	and circuit analys	is.
	 Students can explain characterization tec 	hniques for MOS devices.		
Skills				
	 Students can qualitatively construct energy 	gy band diagrams of the devices for varying a	applied voltages.	
	 Students are able to qualitatively determined 	mine electric field, carrier concentrations,	and charge flow	from energy ba
	diagrams.			
	 Students can understand scientific publication 	ations from the field of semiconductor device	s.	
	Students can calculate the dimensions of	MOS devices in dependence of the circuits pr	operties	
	 Students can design complex electronic c 	ircuits and anticipate possible problems.		
	 Students know procedure for optimization 	regarding high performance and low power	consumption	
Personal Competence				
Social Competence				
	Students can team up with other experts			
		in small groups for solving problems and ans		stions.
	 Students have the ability to critically ques 	tion the value of their contributions to working	ng groups.	
Autonomy	 Students are able to assess their knowled 	ge in a realistic manner.		
	 Students are able to define their personal 			
Workload in Hours	Independent Study Time 124, Study Time in Lec	ture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelectr	onics and Microsystems Technology: Elective	Compulsory	
Following Curricula	International Management and Engineering: Spe	cialisation II. Electrical Engineering: Elective	Compulsory	
	Mechanical Engineering and Management: Spec	alisation Mechatronics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Ele	ctive Compulsory		
	Mechatronics: Core Qualification: Elective Comp	ulsory		
	Microelectronics and Microsystems: Core Qualified	ation: Elective Compulsory		

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

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

Courses						
Title			Тур	Hrs/wk	СР	
Haptic Technology for Human-Machine-Interfaces (HMI) (L2439)			Lecture	4	3	
Haptic Technology for Human-Mach	hine-Interfaces (HMI) (L28	359)	Project-/problem-base	ed Learning 2	3	
Module Responsible	Prof. Thorsten Kern					
Admission Requirements	None					
Recommended Previous	We recommend know	ledge in the areas of	general engineering sciences, mechatron	nics and/or control-er	ngineering. Howev	/er a
Knowledge	neighbouring technica	al areas like mechanic	al-engineering or even process-engineers	can join the course a	nd will be introdu	ced i
	the content properly.					
Educational Objectives	After taking part succ	essfully, students have	e reached the following learning results			
Professional Competence						
Knowledge	This course is an intr	oduction to the desig	n methods and design-requirements to	consider when creat	ing haptic systen	ns fr
5						
	scratch. It covers a physiological part, an actuator development part, and goes up to fundamentals of higher system integration with consideration on control theory for more complex projects. Beside design-related topics, it gives a valuable overview on					
	existing haptic applications and research in that field with many examples. This is supported by on-site experiments in the					
	laboratories of M-4.					
		application of haptic s	systems			
	Haptic perception					
	The role of the user in direct system interaction					
	Development of haptic systems					
	Identification of requirements					
	System-structure and control					
	 Kinematic fundamentals Actuation & Sensors technology for haptic applications 					
	Control and system-design aspects					
	Fundamental c	onsiderations in simul	ating haptics			
Skills	Executing the course	the competency will	be developed to apply the general eng	ineering capabilities	of the individual	cou
	-		tive haptic systems. The resulting comp			
	position in avionic-industries, automotive-industry and consumer-device-development.					
Personal Competence			,			
	As a side-effect this	module teaches basi	cs of a general design for human-machi	ne-interfaces indep	endent from the	snec
			ls to execute user-studies, judge on user			
			ling with subjective perception.			
Autonomy				from a design-persp	ective	
	Independent design-capability of haptic systems, general competency in engineering from a design-perspective Independent Study Time 96, Study Time in Lecture 84					
Credit points		ine 50, Study Time in				
	Compulsory Bonus	Form	Description			
Course achievement	Yes 20 %	Subject theoretica		n		
		practical work				
Examination	Subject theoretical an					
	30 min					
scale						
	Machatropics: Special	isation Intolligent Syst	ems and Robotics: Elective Compulsory			
Assignment for the Following Curricula						
Following Curricula						
	Mechatronics: Core Q	uannication: Elective C	ompuisory			

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

Тур	t-/problem-based Learning		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Thorsten Kern		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M1552: Adva	nced Machine Learning				
	-				
Courses					
Title		Тур	Hrs/wk	СР	
Advanced Machine Learning (L2322		Lecture	2	3	
Advanced Machine Learning (L232		Recitation Section (small)	2	3	
Module Responsible					
Admission Requirements	None				
Recommended Previous	1. Mathematics I-III				
Knowledge	2. Numerical Mathematics 1/ Numerics				
	3. Programming skills, preferably in Python				
-	After taking part successfully, students have rea	iched the following learning results			
Professional Competence					
Knowledge	Students are able to name, state and classify si		esponding mathe	matical basics. The	
Chille	can assess the difficulties of different neural net				
	Students are able to implement, understand, an	a, tailored to the field of application, apply ne	eural networks.		
Personal Competence	Churchangha an m				
Social Competence	Students can				
	develop and document joint solutions in small teams;				
	 form groups to further develop the ideas 	and transfer them to other areas of applicabil	lity;		
	 form a team to develop, build, and advance a software library. 				
Autonomy	Students are able to				
	 correctly assess the time and effort of self-defined work; 				
		I and practical excercises are better solved in	dividually or in a	team;	
	 define test problems for testing and expa 		2		
	 assess their individual progess and, if neo 	essary, to ask questions and seek help.			
Workload in Hours	Independent Study Time 124, Study Time in Lec	ture 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	25 min				
scale					
Assignment for the	Computer Science: Specialisation III. Mathemati	cs: Elective Compulsory			
Following Curricula	Data Science: Core Qualification: Compulsory				
	Computer Science in Engineering: Specialisation	III. Mathematics: Elective Compulsory			
	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Design: Ele	ctive Compulsory			
	Mechatronics: Core Qualification: Elective Comp	ulsory			
	Technomathematics: Specialisation I. Mathemat	ics: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisati	on Robotics and Computer Science: Elective	Compulsory		

Course L2322: Advanced Ma	chine Learning		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	pendent 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, relation to neural ODEs Standard libraries: Tensorflow, Keras, PyTorch Recent trends 		
Literature	 Skript Online-Werke: http://neuralnetworksanddeeplearning.com/ https://www.deeplearningbook.org/ 		

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

Module M1268: Linea	r and Nonlinear Waves				
Courses					
Title		Тур	Hrs/wk	СР	
Linear and Nonlinear Waves (L173	7)	Project-/problem-based Learning	4	6	
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous	Calculus, Algebra, Engineering Mechanics, Vibration	5.			
Knowledge					
Educational Objectives	After taking part successfully, students have reache	d the following learning results			
Professional Competence					
Knowledge	 Chudents are able to reflect evicting terms and co 	aconta in Mayo Machanisa			
	 Students are able to reflect existing terms and co Students are able to identify and express the need 		to		
	• Students are able to identify and express the neer				
Skills					
	 Students are able to apply existing research meth Students are able to develop novel research meth 				
	 Students are able to develop hovel research metric 	ous and procedures in wave mechanics.			
Personal Competence					
Social Competence	Students can reach working results also in groups.				
	 Students can present and communicate work 	ng results also in groups.			
Autonomy					
	 Students are able to approach given research task Students are able to identify and following approach 				
	 Studetns are able to identify and follow up novel r 	esearch tasks 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	Mechatronics: Specialisation System Design: Elective	e Compulsory			
Following Curricula	Mechatronics: Core Qualification: Elective Compulso	гу			
	Naval Architecture and Ocean Engineering: Core Qua	alification: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation N	laritime Technology: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation S	imulation Technology: Elective Compulsory			

Course L1737: Linear and No	ourse L1737: Linear and Nonlinear Waves			
Тур	Project-/problem-based Learning			
Hrs/wk	4			
CP	6			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Lecturer	Prof. Norbert Hoffmann			
Language	DE/EN			
Cycle	WiSe			
Content	Introduction into the Dynamics of Linear and Nonlinear Waves			
	Linear Waves			
	Dispersion			
	Phase and Group Velocity			
	Envelopes Disperte Sustance			
	Discrete Systems Nonlinear Waves			
	Model Equations			
	Solitons, Breathers, Extreme Waves			
	Water Waves, Ocean Waves			
	Airy and Stokes			
	Natural Sea State			
	Kinetic Modelling			
	Other topics			
Literature	F.K. Kneubühl: Oscillations and Waves. Springer.			
	G.B. Witham, Linear and Nonlinear Waves. Wiley.			
	C.C. Mei, Theory and Applications of Ocean Surface Waves. World Scientific.			
	L.H. Holthuijsen, Waves in Oceanic and Coastal Waters. Cambridge.			
	And others.			

Courses					
Title		Тур	Hrs/wk	СР	
Mathematical Image Processing (L	.0991)	Lecture	3	4	
Mathematical Image Processing (L	.0992)	Recitation Section (small)	1	2	
Module Responsible	Prof. Marko Lindner				
Admission Requirements	None				
Recommended Previous					
Knowledge					
	Linear Algebra: eigenvalues, least	squares solution of a linear system			
Educational Objectives	After taking part successfully, students h	ave reached the following learning results			
Professional Competence					
-	Students are able to				
	characterize and compare diffusion				
	explain elementary methods of im				
	explain methods of image segmen				
	sketch and interrelate basic conce	pts of functional analysis			
Skills	Students are able to				
	implement and apply elementary methods of image processing				
	 explain and apply modern method 	s of image processing			
Personal Competence					
Social Competence	Students are able to work together i	n heterogeneously composed teams (i.e., team	s from different	study programs a	
	background knowledge) and to explain the	eoretical foundations.			
Autonomy	,				
Autonomy		their understanding of complex concepts on their	r own. They can sp	pecify open question	
	precisely and know where to get h	elp in solving them.			
	Students have developed sufficient	nt persistence to be able to work for longer peri	ods in a goal-orier	nted manner on ha	
	problems.				
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56			
Credit points					
Course achievement					
Examination	Oral exam				
Examination duration and	20 min				
scale					
Assignment for the	Bioprocess Engineering: Specialisation A	- General Bioprocess Engineering: Elective Compu	lsory		
Following Curricula					
	Computer Science in Engineering: Specia	lisation III. Mathematics: Elective Compulsory			
	Interdisciplinary Mathematics: Specialisat	tion Computational Methods in Biomedical Imaging	g: Compulsory		
	Mechatronics: Specialisation Intelligent S	ystems and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Des	gn: Elective Compulsory			
	Mechatronics: Core Qualification: Elective				
	Technomathematics: Specialisation I. Mat				
		cialisation Robotics and Computer Science: Electiv	e Compulsory		

Course L0991: Mathematical	Image Processing
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	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	ourse L0992: Mathematical Image Processing		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Marko Lindner		
Language	DE/EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0720: Matri	x Algorithms				
Courses					
Title		Тур	Hrs/wk	СР	
Matrix Algorithms (L0984)		Lecture	2	3	
Matrix Algorithms (L0985)		Recitation Section (small)	2	3	
Module Responsible	Dr. Jens-Peter Zemke				
Admission Requirements	None				
Recommended Previous	Mathematics -				
Knowledge	Numerical Mathematics 1/ Numerics				
	Basic knowledge of the programming la	anguages Matlab and C			
Educational Objectives	After taking part successfully, students have	reached the following learning results			
Professional Competence					
Knowledge	Students are able to				
	1. name, state and classify state-of-the-a	rt Krylov subspace methods for the solution of	of the core probler	ns of the engineerin	
	sciences, namely, eigenvalue problems	s, solution of linear systems, and model reduct	ion;		
	2. state approaches for the solution of ma	atrix equations (Sylvester, Lyapunov, Riccati).			
Skille	Students are capable to				
SKIIIS	Students are capable to				
	 implement and assess basic Krylov subspace methods for the solution of eigenvalue problems, linear systems, reduction; 				
		are with respect to computing time, stability, a	ind domain of appl	icability;	
	adapt the approaches learned to new,	unknown types of problem.			
Personal Competence					
Social Competence	Students can				
	- develop and decument isint colutions i	n amall kaoma			
	 develop and document joint solutions i form groups to further dovelop the idea 	as and transfer them to other areas of applical	bility		
	 form a team to develop, build, and adv 		onicy,		
		ance a soluwire nordry.			
Autonomy	Students are able to				
	correctly assess the time and effort of	self-defined work:			
		ical and practical excercises are better solved	individually or in a	team;	
	define test problems for testing and ex		-		
	• assess their individual progess and, if r	necessary, to ask questions and seek help.			
Workload in Hours	Independent Study Time 124, Study Time in I	octuro F6			
Workload in Hours Credit points					
Course achievement					
Examination					
Examination duration and					
scale					
	Computer Science: Specialisation III. Mathema	atics: Elective Compulsory			
Following Curricula					
	Data Science: Specialisation I. Mathematics: B				
	Mechatronics: Specialisation Intelligent System	ms and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Design:	Elective Compulsory			
	Mechatronics: Core Qualification: Elective Cor	npulsory			
	Technomathematics: Specialisation I. Mathem				
	Theoretical Mechanical Engineering: Specialis	ation Simulation Technology: Elective Compul	sory		

Course L0984: Matrix Algorit	hms
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	 Part A: Krylov Subspace Methods: Basics (derivation, basis, Ritz, OR, MR) Arnoldi-based methods (Arnoldi, GMRes) Lanczos-based methods (Lanczos, CG, BiCG, QMR, SymmLQ, PvL) Sonneveld-based methods (IDR, BiCGStab, TFQMR, IDR(s)) Part B: Matrix Equations: Sylvester Equation Lyapunov Equation Algebraic Riccati Equation
Literature	 Skript (224 Seiten) Ergänzend können die folgenden Lehrbücher herangezogen werden: Saad, Yousef. Numerical methods for large eigenvalue problems: revised edition. Society for Industrial and Applied Mathematics, 2011. Saad, Yousef. Iterative methods for sparse linear systems. Society for Industrial and Applied Mathematics, 2003. Van der Vorst, Henk A. Iterative Krylov methods for large linear systems. No. 13. Cambridge University Press, 2003. Liesen, Jörg, and Zdenek Strakos. Krylov subspace methods: principles and analysis. Oxford University Press, 2013.

Course L0985: Matrix Algorithms		
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Jens-Peter Zemke	
Language	DE/EN	
Cycle	WiSe	
Content		
Literature	Siehe korrespondierende Vorlesung	

Courses					
Title		Тур	Hrs/wk	СР	
Methods of Product Development (L1254)		Lecture	3	3	
Methods of Product Development (Project-/problem-based Learning	2	3	
Module Responsible	Prof. Dieter Krause				
Admission Requirements	None				
Recommended Previous	Basic knowledge of Integrated product developmen	and applying CAE systems			
Knowledge					
Educational Objectives	After taking part successfully, students have reache	d the following learning results			
Professional Competence					
Knowledge	After passing the module students are able to:				
	explain technical terms of design methodolog	ιγ,			
	 describe essential elements of construction n 	nanagement,			
	describe current problems and the current st	ate of research of integrated product develop	ment.		
Skills	After passing the module students are able to:				
	 select and apply proper construction method 	ds for non-standardized solutions of problem	is as well as	adapt new bounda	
	conditions,				
	 solve product development problems with the 	e assistance of a workshop based approach,			
	choose and execute appropriate moderation techniques.				
Personal Competence					
	After passing the module students are able to:				
Social competence	Arter pussing the module stadents are usic to.				
	 prepare and lead team meetings and modera 	tion processes,			
	 work in teams on complex tasks, 				
	 represent problems and solutions and advance 	ce ideas.			
Autonomy	After passing the module students are able to:				
	 give a structured feedback and accept a critical feedback, 				
	 implement the accepted feedback autonomo 				
Workload in Hours	Independent Study Time 110, Study Time in Lecture	. 70			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	30 Minuten				
scale					
Assignment for the	Aircraft Systems Engineering: Core Qualification: Ele	ective Compulsory			
Following Curricula	International Management and Engineering: Special		on: Elective C	ompulsory	
	Aeronautics: Core Qualification: Elective Compulsor				
	Mechatronics: Specialisation System Design: Electiv	e Compulsory			
	Mechatronics: Core Qualification: Elective Compulse	ry			
	Product Development, Materials and Production: Sp	ecialisation Product Development: Compulsor	У		
	Product Development, Materials and Production: Sp	ecialisation Production: Elective Compulsory			
	Product Development, Materials and Production: Sp	ecialisation Materials: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation I	Product Development and Production: Elective	e Compulsory		

Course L1254: Methods of Pr	oduct Development
Тур	Lecture
Hrs/wk	3
CP	3
	Independent Study Time 48, Study Time in Lecture 42
	Prof. Dieter Krause
Language	
Cycle	
Content	Lecture
	The lecture extends and enhances the learned content of the module "Integrated Product Development and lightweight design"
	and is based on the knowledge and skills acquired there.
	Topics of the course include in particular:
	Methods of product development,
	Presentation techniques,
	Industrial Design, Design for work to be a set of the set
	Design for variety
	Modularization methods,
	Design catalogs, Advated OSD matrix
	Adapted QFD matrix, Subtraction protocols and a strengthered and a strengeheet and a strengthered and a strengthered and a strengthered a
	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 everyice the content precented in the lecture "Integrated Braduct Development II" and mathede of product development and
	In the exercise the content presented in the lecture "Integrated Product Development II" and methods of product development and design management will be enhanced.
	uesign management win be ennanced.
	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.
	not knop based as decare of the order the one planning and management.
Literature	
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 2013.

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

Module M0746: Micro	system	Engine	ering				
Courses							
Title					Түр	Hrs/wk	СР
Microsystem Engineering (L0680)					Lecture	2	4
Microsystem Engineering (L0682)					Project-/problem-based Learning	2	2
Module Responsible	Dr. Timo Li	ipka					
Admission Requirements	None						
Recommended Previous	Basic cours	ses in phys	ics, mathematic	s and electric engineering			
Knowledge							
Educational Objectives	After takin	g part succ	essfully, student	s have reached the followi	ng learning results		
Professional Competence							
Knowledge	The studer	nts know a	bout the most i	important technologies and	d materials of MEMS as well a	s their applica	tions in sensors ar
	actuators.						
Chille	Chudonto d	ava abla ta	analyza and a	lessibe the functional he	haviour of MEMC components	ممط المم من ما ا	ata tha natantial
SKIIIS	microsyste		analyze and d	lescribe the functional be	haviour of MEMS components	and to evaluate	ate the potential
	microsyste	:115.					
Personal Competence							
Social Competence	Students a	re able to s	solve specific pro	blems alone or in a group	and to present the results accor	dingly.	
Autonomy	Studonte a	ro ablo to	acquiro particul:	ar knowlodgo using sposial	ized literature and to integrate	and accoriate	this knowledge wi
Autonomy	other fields			ar knowledge dsing special			this knowledge wi
Workload in Hours	Independe	nt Study Ti	me 124, Study T	ime in Lecture 56			
Credit points							
Course achievement	Compulsory		Form	Description			
	No	10 %	Presentation				
Examination		am					
Examination duration and	2h						
scale							
Assignment for the							
Following Curricula		-	-		ctrical Engineering: Elective Co		
		-	-		chatronics: Elective Compulsory	/	
		-			tronics: Elective Compulsory		
			-	Design: Elective Compulsor	У		
				tive Compulsory	Compulsory		
			-	ore Qualification: Elective (llconv	
	rileorerica	i mechanici	ai Engineering: S	סארים אונים שומי אונים אונים אונים אינים איני אינים אינים איני	ical Technology: Elective Comp	usory	

Course L0680: Microsystem	Engineering						
Тур	Lecture						
Hrs/wk	2						
СР	4						
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28						
Lecturer	Dr. Timo Lipka						
Language	EN						
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						
CP	2					
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28					
Lecturer	Dr. Timo Lipka					
Language	EN					
Cycle	WiSe					
Content	Examples of MEMS components					
	Layout consideration					
	Electric, thermal and mechanical behaviour					
	Design aspects					
Literature	Wird in der Veranstaltung bekannt gegeben					

Courses						
Title		Typ	Hrs/wk	СР		
Flexible Multibody Systems (L1632)		Typ Lecture	2	3		
Optimization of dynamical systems		Lecture	2	3		
Module Responsible	Prof. Robert Seifried					
Admission Requirements	None					
Recommended Previous						
Knowledge	Mathematics I, II, III					
-	Mechanics I, II, III, IV					
	 Simulation of dynamical Systems 					
Educational Objectives	After taking part successfully, students have rea	ched the following learning results				
Professional Competence	51 5.	5 5				
	Students demonstrate basic knowledge and ur	nderstanding of modeling, simulation	n and analysis of comp	lex rigid and flexit		
5	multibody systems and methods for optimizing of			5		
Skills	Students are able					
	+ to think holistically					
	+ to independently, securly and critically analyze and optimize basic problems of the dynamics of rigid and flexible multibody					
	systems					
	+ to describe dynamics problems mathematically					
	+ to optimize dynamics problems					
	+ to optimize dynamics problems					
Personal Competence						
Social Competence	Students are able to					
	+ solve problems in heterogeneous groups and	a document the corresponding result	-c			
	r solve problems in neterogeneous groups and	to document the corresponding result				
Autonomy	Students are able to					
Autonomy						
	+ assess their knowledge by means of exercises					
	+ acquaint themselves with the necessary know	ledge to solve research oriented task	s.			
		5				
Workload in Hours	Independent Study Time 124, Study Time in Lec	ture 56				
Credit points	6					
Course achievement	None					
Examination	Oral exam					
Examination duration and	30 min					
scale						
Assignment for the	Aircraft Systems Engineering: Core Qualification	Elective Compulsory				
Following Curricula	Aeronautics: Core Qualification: Elective Comput	sory				
	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory				
	Mechatronics: Specialisation System Design: Ele	ctive Compulsory				
	Mechatronics: Core Qualification: Elective Comp	llsory				
	Product Development, Materials and Production:		ory			
	Theoretical Mechanical Engineering: Core Qualifi	cation: Elective Compulsory				

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

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

Courses				_				
Fitle				Тур	Hrs/wk	СР		
Optics for Engineers (L2437) Optics for Engineers (L2438)				Lecture Project-/problem-based Learning	3 3	3 3		
	Prof. Thorsten Kern			Troject-problem-based Learning	5	5		
Module Responsible Admission Requirements	None							
Recommended Previous	- Basics of physics							
Keconmended Previous	- basics of physics							
5	After telving next gues		reached the followin	a laavning vaculta				
Educational Objectives	After taking part succ	cessfully, students have	reached the following	ig learning results				
Professional Competence								
Knowledge	leaching subject ist t	the design of simple opti-	cal systems for illun	nination and imaging optics				
	Basic values for	or optical systems and lig	ghting technology					
	 Spectrum, black 	ck-bodies, color-percepti	on					
	 Light-Sources up 	und their characterizatio	in					
	 Photometrics 							
	 Ray-Optics 							
	 Matrix-Optics 							
	 Stops, Pupils a 	nd Windows						
	 Light-field Tech 	hnology						
	 Introduction to 	Wave-Optics						
	 Introduction to 	Introduction to Holography						
Skills	Understandings of op	tics as part of light and e	electromagnetic spe	ectrum. Design rules, approach t	o designing op	otics		
Personal Competence								
Social Competence								
Autonomy								
Workload in Hours	Independent Study Ti	ime 96, Study Time in Le	ecture 84					
Credit points								
Course achievement	Compulsory Bonus	Form	Description					
course acmevement	Yes None	Subject theoretical		Laborübungen und Simulation				
		practical work		<u> </u>				
Examination	Oral exam	p						
Examination duration and	30 min							
scale	50 11111							
564.6	Electrical Engineering	: Specialisation Microwa		tics, and Electromagnetic Comp	atibility: Electi	ve Compulsory		
Following Curricula		lisation Intelligent System			anomity. Lietti	ve compuisory		
ronowing curricula		lisation System Design:						
		ualification: Elective Cor		/				
	mechacionics. core Q	damication. Elective Col	iipuisoi y					

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

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

Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Structural Analysis (L027	7)	Lecture	3	4
Nonlinear Structural Analysis (L027	9)	Recitation Section (small)	1	2
Module Responsible	Prof. Alexander Düster			
Admission Requirements	None			
Recommended Previous	Knowledge of partial differential equations i	s recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
Knowledge	Students are able to			
	+ give an overview of the different nonlinea	ar phenomena in structural mechanics.		
	+ explain the mechanical background of no	nlinear phenomena in structural mechanics.		
	+ to specify problems of nonlinear structur	al analysis, to identify them in a given situation a	and to explain the	eir mathematical a
	mechanical background.			
Skills	Students are able to			
	+ model nonlinear structural problems.			
	+ select for a given nonlinear structural pro	blem a suitable computational procedure.		
	+ apply finite element procedures for nonlin			
	+ critically verify and judge results of nonlir			
	+ to transfer their knowledge of nonlinear s			
	_			
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous groups.			
	+ present and discuss their results in front			
	+ give and accept professional constructive	criticism.		
Autonomy	Students are able to			
	+ assess their knowledge by means of exer	cises and E-Learning.		
	+ acquaint themselves with the necessary I	knowledge to solve research oriented tasks.		
	+ to transform the acquired knowledge to s	imilar problems.		
Workload in Hours	Independent Study Time 124, Study Time in	n Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Civil Engineering: Specialisation Structural B	Engineering: Elective Compulsory		
Following Curricula	Civil Engineering: Specialisation Computation	onal Engineering: Compulsory		
	International Management and Engineering	Specialisation II. Civil Engineering: Elective Comp	oulsory	
	Materials Science: Specialisation Modeling:	Elective Compulsory		
	Mechatronics: Technical Complementary Co	ourse: Elective Compulsory		
	Mechatronics: Specialisation System Design	: Elective Compulsory		
	Mechatronics: Core Qualification: Elective C	ompulsory		
	Product Development, Materials and Product	tion: Core Qualification: Elective Compulsory		
	Naval Architecture and Ocean Engineering:	Core Qualification: Elective Compulsory		
	Ship and Offshore Technology: Core Qualified	ation: Elective Compulsory		
	Theoretical Mechanical Engineering: Specia	lighting Circulation Technology, Floctive Compulse	- MD - 4	

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

Course L0279: Nonlinear Str	urse L0279: Nonlinear Structural Analysis		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Alexander Düster		
Language	DE/EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M1229: Conti	rol Lab B			
-				
Courses				
Title		Тур	Hrs/wk	СР
Control Lab V (L1667)		Practical Course	1	1
Control Lab VI (L1668)		Practical Course	1	1
Module Responsible				
Admission Requirements				
Recommended Previous	 State space methods 			
Knowledge	LQG control			
	 H2 and H-infinity optimal control 	l.		
	uncertain plant models and robu			
	LPV control			
Educational Objectives	After taking part successfully, students	s have reached the following learning results		
Professional Competence				
Knowledge				
	 Students can explain the differe 	nce between validation of a control lop in simulati	on and experimental v	alidation
Skills				
on no	 Students are capable of apply 	ing basic system identification tools (Matlab System)	stem Identification To	olbox) to identif
	dynamic model that can be used	d for controller synthesis		
	 They are capable of using star 	ndard software tools (Matlab Control Toolbox) fo	r the design and imp	elementation of l
	controllers			
	 They are capable of using stand 	dard software tools (Matlab Robust Control Toolbo>	() for the mixed-sensition	tivity design and
	implementation of H-infinity opt	imal controllers		
	 They are capable of representin 	g model uncertainty, and of designing and implem	enting a robust contr	oller
	 They are capable of using stand 	lard software tools (Matlab Robust Control Toolbox) for the design and th	e implementation
	LPV gain-scheduled controllers			
Personal Competence				
Social Competence	 Students can work in teams to c 	conduct experiments and document the results		
		·		
Autonomy	 Students can independently car 	ry out simulation studies to design and validate co	ntrol loops	
	· Students can independently can	ry out simulation statics to design and validate ee		
Workload in Hours	Independent Study Time 32, Study Tim	ne in Lecture 28		
Credit points	2			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	1			
scale				
Assignment for the	Electrical Engineering: Specialisation C	Control and Power Systems Engineering: Elective C	ompulsory	
Following Curricula				
		t Systems and Robotics: Elective Compulsory		
	and a second sec	.,		

Course L1667: Control Lab V		
Тур	Practical Course	
Hrs/wk	1	
CP	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	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	Course L1668: Control Lab VI		
Тур	Practical Course		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Herbert Werner, Adwait Datar, Patrick Göttsch		
Language	EN		
Cycle	WiSe/SoSe		
Content	One of the offered experiments in control theory.		
Literature	Experiment Guides		

Courses							
Title				Тур		Hrs/wk	СР
Advanced Topics in Control (L1803)				Seminar		2	2
Module Responsible	NN						
Admission Requirements							
Recommended Previous Knowledge	•	Introduction to contro Control theory and d optimal and robust c	esign				
Educational Objectives	After t	aking part successful	ly, students have reach	ed the following learning r	esults		
Professional Competence Knowledge		Students can explain Students learn to app	modern control. bly basic control conce	ots 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			e of developing solution vide appropriate feedba	s and present them ick and handle constructive	e criticism of their ov	vn results	
Autonomy	 Students evaluate advantages and drawbacks of different forms of presentation for specific tasks and select the be solution Students familiarize themselves with a scientific field, are able of introduce it and follow presentations of other student such that a scientific discussion develops 						
Workload in Hours	Indepe	endent Study Time 32	, Study Time in Lecture	28			
Credit points	2						
Course achievement	None						
Examination	Preser	ntation					
Examination duration and scale	90 mir	ı					
Assignment for the	Mecha	tronics: Specialisatio	n Intelligent Systems a	nd Robotics: Elective Comp	oulsory		
Following Curricula			n System Design: Elect ation: Elective Compuls				

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	NN	
Language	EN	
Cycle	WiSe/SoSe	
Content	Seminar on selected topics in modern control	
Literature	To be specified	

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. Benedikt Kriegesmann				
Admission Requirements	None				
Recommended Previous	Technical Acoustics I (Acoustic Waves, Noise Prote	ction, Psycho Acoustics)			
Knowledge		la changing II (II) due chating - King angeting - Due			
	Mechanics I (Statics, Mechanics of Materials) and N	iechanics II (Hydrostatics, Kinematics, Dyn	amics)		
	Mathematics I, II, III (in particular differential equat	ions)			
Educational Objectives	After taking part successfully, students have reach	ed the following learning results			
Professional Competence					
	The students possess an in-depth knowledge in a	coustics regarding room acoustics and co	mputational met	hods and are able	
	e The students possess an in-depth knowledge in acoustics regarding room acoustics and computational methods and are able give an overview of the corresponding theoretical and methodical basis.				
	g				
Skills	Skills The students are capable to handle engineering problems in acoustics by theory-based application of the			of the demand	
	computational methods and procedures treated wi	thin the module.			
Personal Competence					
Social Competence	Students can work in small groups on specific prob	lems to arrive at joint solutions.			
Autonomy	The students are able to independently solve cha		s treated within	the module. Poss	
	conflicting issues and limitations can be identified	and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Time in Lectur	re 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	20 min				
scale					
Assignment for the	Aircraft Systems Engineering: Core Qualification: E	lective Compulsory			
Following Curricula	Aeronautics: Core Qualification: Elective Compulso	ry			
	Mechatronics: Specialisation System Design: Electi	ve Compulsory			
	Mechatronics: Core Qualification: Elective Compuls	ory			
	Product Development, Materials and Production: Co	ore Qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation	Product Development and Production: Elec	ctive Compulsory		
	Theoretical Mechanical Engineering: Specialisation	Simulation Technology, Elective Compulse			

Course L0519: Technical Aco	ustics II (Room Acoustics, Computational Methods)		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	lependent Study Time 62, Study Time in Lecture 28		
Lecturer	DrIng. Sören Keuchel		
Language	EN		
Cycle	WiSe		
Content	- Room acoustics		
	- Sound absorber		
	- Standard computations		
	- Statistical Energy Approaches		
	- Finite Element Methods		
	- Boundary Element Methods		
	- Geometrical acoustics		
	- Special formulations		
	- Practical applications		
	- Hands-on Sessions: Programming of elements (Matlab)		
Literature	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin		
	Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg		
	Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg		
	Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden		
	Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin		

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

Courses						
Title		Тур	Hrs/wk	СР		
Fundamentals of Maintenance, Rep	pair and Overhaul (MRO) (L3160)	Lecture	3	4		
Fundamentals of Maintenance, Rep	pair and Overhaul (MRO) (L3161)	Recitation Section (large)	1	2		
Module Responsible	Prof. Gerko Wende					
Admission Requirements	None					
Recommended Previous	We recommend knowledge in the areas of general engineering sciences, aeronautics and aircraft systems engineering. Technic					
Knowledge	fields like mechanical engineering, mechatronics	and production engineering will be intro	duced into the	relevant aeronauti		
	content.					
Educational Objectives	After taking part successfully, students have reache	ed the following learning results				
Professional Competence		5 5				
Knowledge	The students are able to describe fundamental corr	elations for the sustainable operation of te	echnical assets ar	nd to identify solut		
	approaches for complex optimization problems.					
CI-111-						
SKIIIS	5 The students are enabled to apply the general engineering capabilities of the individual course towards the optimization of the					
	sustainability in operation of technical assets. The resulting competencies will open an entry into positions in the developmen production and technical operation of sustainable products in the mobility and engineering industries.					
	production and technical operation of sustainable p	roducts in the mobility and engineering in	austries.			
Personal Competence						
Social Competence	The students are able to work in mixed groups with a clear focus on the approached solutions by respecting the comple					
	environment of multiple stakeholders.					
Autonomy	The students are enabled to find colutions for	potimization problems and to take requ	urad docision for	the according		
Autonomy	The students are enabled to find solutions for optimization problems and to take required decision for the assessment determining factors independently.					
	determining factors independently.					
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	30 min					
scale						
Assignment for the	Aircraft Systems Engineering: Core Qualification: El	ective Compulsory				
Following Curricula	Aeronautics: Core Qualification: Elective Compulsor	У				
	Mechatronics: Specialisation Intelligent Systems an	d Robotics: Elective Compulsory				
	Mechatronics: Specialisation System Design: Elective	ve Compulsory				
	Mechatronics: Core Qualification: Elective Compulse	ory				
	Product Development, Materials and Production: Sp					
	Product Development, Materials and Production: Sp	ecialisation Production: Elective Compulso	ory			
	Product Development, Materials and Production: Sp					
	Theoretical Mechanical Engineering: Specialisation					
	Theoretical Mechanical Engineering: Specialisation	Aircraft Systems Engineering: Elective Cor	npulsory			

Course L3160: Fundamentals	ourse L3160: Fundamentals of Maintenance, Repair and Overhaul (MRO)			
Тур	cture			
Hrs/wk				
CP	4			
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42			
Lecturer	Prof. Gerko Wende			
Language	DE			
Cycle	ViSe			
Content	Fundamentals for the sustainable operation of technical assets by means of maintenance, repair and overhaul (MRO):			
	 Life cycle analytics Material circularity and service products Rules and regulations Processes and production methods Tools and technologies Data handling and usage Design for maintenance Self-healing technical systems 			
Literature	•			

Course L3161: Fundamentals of Maintenance, Repair and Overhaul (MRO)		
Тур	Recitation Section (large)	
Hrs/wk	1	
CP	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Gerko Wende	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Thesis Module M-002: Master Thesis		
Title	Typ Hrs/wk CP	
Module Responsible	Professoren der TUHH	
Admission Requirements	A compliants Communications (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 or research. 	
Skills	The students are able:	
	 To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question. To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/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	
Autonomy	 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. Students are able: 	
	 To structure a project of their own in work packages and to work them off accordingly. To work their way in depth into a largely unknown subject and to access the information required for them to do so. To apply the techniques of scientific work comprehensively in research of their own. 	
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0	
Credit points	30	
Course achievement	None	
Examination	Thesis	
Examination duration and	According to General Regulations	
scale		
Assignment for the		
Following Curricula	Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory	
	Computer Science: Thesis: Compulsory	
	Data Science: Thesis: Compulsory	
	Electrical Engineering: Thesis: Compulsory	
	Energy Systems: Thesis: Compulsory	
	Environmental Engineering: Thesis: Compulsory	
	Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory	
	Computer Science in Engineering: Thesis: Compulsory	
	Information and Communication Systems: Thesis: Compulsory	
	Interdisciplinary Mathematics: Thesis: Compulsory	
	International Production Management: Thesis: Compulsory	
	International Management and Engineering: Thesis: Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory	
	Logistics, Infrastructure and Mobility: Thesis: Compulsory	
	Aeronautics: Thesis: Compulsory	
	Materials Science and Engineering: Thesis: Compulsory	
	Materials Science: Thesis: Compulsory	
	Mechanical Engineering and Management: Thesis: Compulsory Mechatronics: Thesis: Compulsory	
	Biomedical Engineering: Thesis: Compulsory	

Microelectronics and Microsystems: Thesis: Compulsory
Product Development, Materials and Production: Thesis: Compulsory
Renewable Energies: Thesis: Compulsory
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